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EOLOGY OF THE LYSIAN PARK-REPETTO HILLS AREA, LOS ANGELES COUNTY, CALIFORNIA

DEPARTMENT OF CONSERVATION
DIVISION OF MINES AND GEOLOGY
THE GREAT SEAL OF THE STATE OF CALIFORNIA
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SPECIAL REPORT 101

California Division of Mines and Geology,
Ferry Building, San Francisco, 1970

GEOLOGY OF THE ELYSIAN PARK-REPETTO HILLS AREA, LOS ANGELES COUNTY, CALIFORNIA

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ABSTRACT

The Elysian Park-Repetto Hills area is situated in a group of low hills at the northern edge of the Los Angeles basin. These hills and the intervening lowlands comprise a densely populated portion of metropolitan Los Angeles.

The basement rocks consist of massive granodiorite and quartz diorite in the northwest portion of the area and, to the east, gneissic quartz diorite and minor amounts of schist and granodiorite. The basement rocks are faulted against sedimentary rocks along the Hollywood, Eagle Rock and San Rafael faults. The thickness and lithology of sedimentary rock units differ within individual fault blocks. Directly north of the York Boulevard fault, sedimentary breccia rests on quartz diorite, which in turn is overlain by a maximum of 5500 feet of conglomerate and interfingered sandstone assigned to the Topanga Formation (middle Miocene). These rocks had a source to the north-northwest and yield fish scales characteristic of forms found in rocks of the Relizian and Luisian Stages. South of the York Boulevard fault, the Topanga Formation consists of conglomerate interfingered with rhythmically bedded siltstone and sandstone. The fine-grained rocks have yielded Foraminifera and fish scales of Luisian and possible Mohnian age.

Northeast of the northwest-trending Highland Park fault the Topanga Formation is overlain unconformably by the Puente Formation (upper Miocene). The Puente Formation in this fault block consists of basal conglomeratic sandstone overlain by interfingered siliceous and diatomaceous shale and siltstone. This sequence is approximately 2000 feet thick and has yielded microfossils characteristic of the Mohnian and possibly the Delmontian Stages. Southwest of the Highland Park fault the Puente Formation has a maximum thickness of 8500 feet. In the subsurface a basal conglomerate rests on the Toponga Formation and rocks correlated with the Santa Monica Slate (Jurassic and Triassic?). The surface and subsurface relationships suggest that the Mohnian-Luisian Stage boundary represents a difference in environment related more to position than to passage of time. The middle portion of the Puente Formation consists largely of sandstone which was deposited during the Mohnian Stage by south-southeast-flowing turbidity currents in water several thousand feet deep. These rocks comprise the southeast lobe of the ancient Tarzana submarine fan described in the Santa Monica Mountains by Sullwold (1960). The upper portion of the Puente Formation consists of siltstone with interfingered conglomerate and sandstone which had a source to the northeast.

In the southern part of the area the Puente Formation is overlain unconformably by the Fernando Formation of Pliocene age. Locally the base of the Fernando is comformable. The Fernando consists of massive siltstone overlain by conglomerate and sandstone. The thickness increases from 1000 feet in the western portion of the area to more than 6000 feet at the eastern edge of the area. The relative percentage of conglomerate and sandstone also increases to the east. The Fernando was deposited in deep water by turbidity currents flowing from the east. A fault block of approximately 1500 feet of Fernando conglomerate and sandstone yielding probable Pliocene megafossils is present in the north central portion of the area between the Highland Park and York Boulevard faults. An exposure of sandstone on Raymond Hill, which contains probable Pliocene megafossils, is also assigned to the Fernando Formation. These rocks were deposited in a shallow water and nonmarine environment.

Alluvium and dissected alluvial terrace deposits are present in the lowland areas. These rocks consist of poorly consolidated gravel, sand, and silt. Three landslides were

mapped in Griffith Park in the northwest part of the area and another was mapped in Elysian Park along the southwest side of the Los Angeles River.

Several major northwest-trending faults assumed to represent the northwest continuation of the Whittier fault system cross the area. In the central portion of the area these faults usually offset the east and northeast striking faults of the Santa Monica fault system. Vertical separation on individual faults commonly amounts to thousands of feet. The maximum vertical separation, about 10,000 feet, may occur across the York Boulevard fault where basement rock is faulted against Pliocene rocks. The complicated mosaic of intersecting faults may be the result of major strike-slip on the Whittier and Santa Monica fault systems. The folds are the result of drag related to fault movement. The structural relations indicate that movement occurred along different faults from late Miocene into the Quaternary. The most recent movement has occurred along the San Rafael, Eagle Rock and Raymond Hill faults in the north and northeast portion of the area.

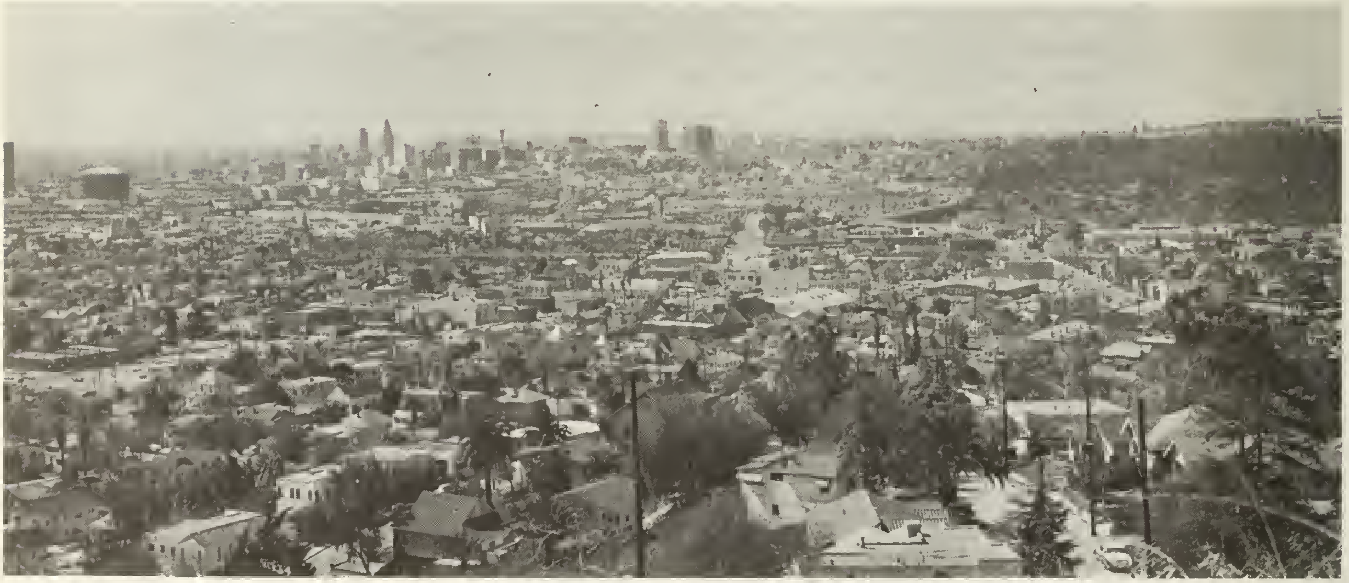

Figure 1. View of Los Angeles Basin. The Elysian Park Hills appear on the right, in this southwest view. Beyond the Los Angeles Civic Center, the Palos Verdes Hills show faintly in the background.

GEOLOGY OF THE ELYSIAN PARK-REPETTO HILLS AREA, LOS ANGELES COUNTY, CALIFORNIA

By DONALD L. LAMAR

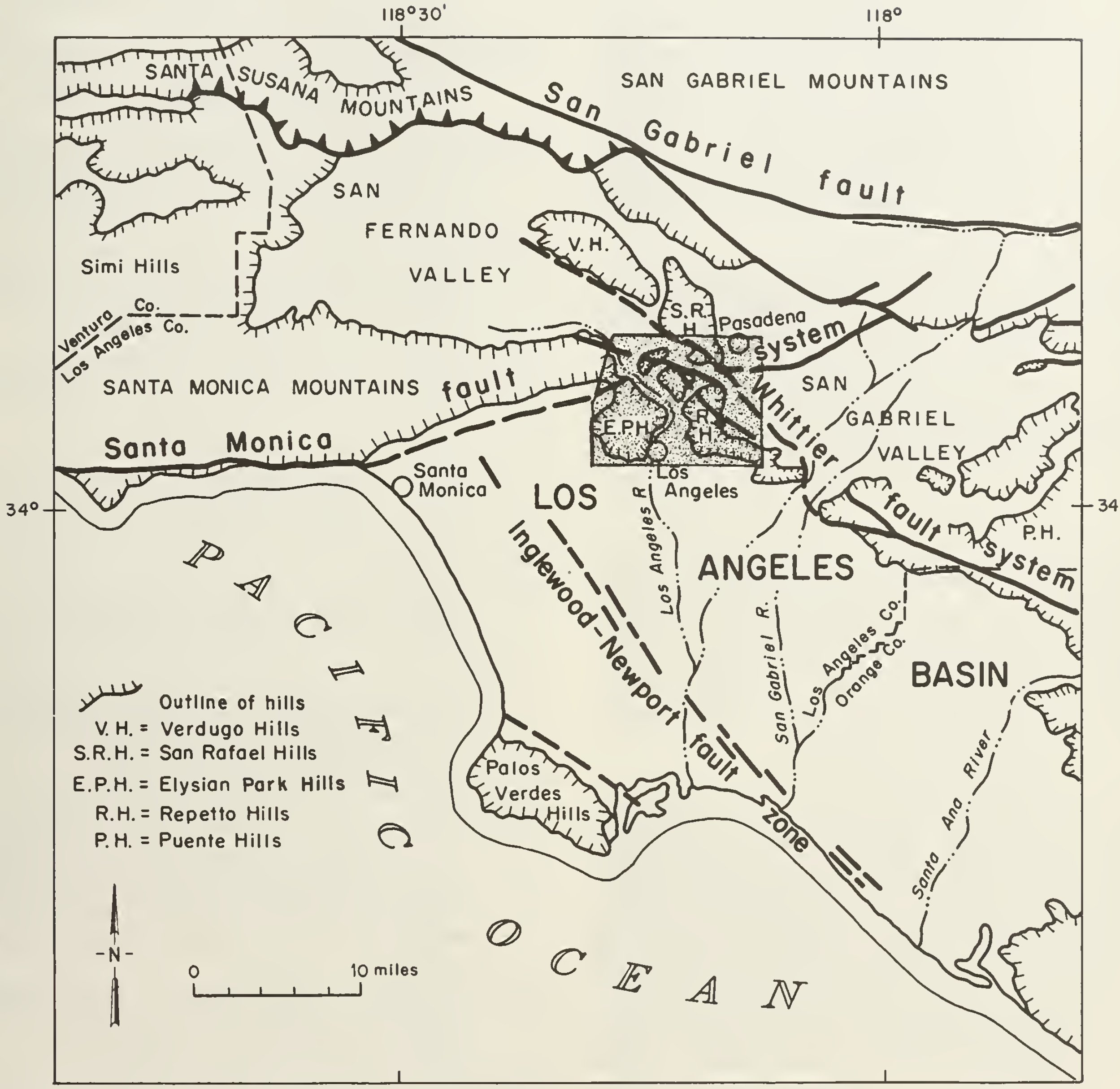

Figure 2. Index Map. The Elysian Park-Repetto Hills area is shaded. The map is modified from Kundert (1955) and Yerkes *et al.* (1965), figure 2.

INTRODUCTION

Location and Purpose of Study

The Los Angeles basin is bounded on the north and east by mountains and hills and on the southwest by the Pacific Ocean and Palos Verdes Hills (figs. 1 and 2). Major fault zones are located close to the margins of the basin along most of the north, northeast, and a portion of the southwest edges. The central part of the basin contains a very thick section of upper Miocene through Pleistocene sediments, which are either thin or absent on much of the topographically high area around the basin. It has been suggested (Barbat, 1958; Hill and Dibblee, 1953) that the Santa Monica and Whittier fault systems, which are located near the margins of the basin, have had major components of strike-slip. In the older rocks, this displacement could be of the same order of magnitude as the present basin dimensions. Although the surface and subsurface geology of the Los Angeles basin area has been intensively studied in recent decades, the only published geologic maps of the northern margin of the basin, in the foothills between the Santa Monica Mountains and Puente Hills, consist of a compilation (Woodford *et al.*, 1954) of mapping from various sources, and small scale maps prepared by Woodring (1938) and Eldridge and Arnold (1907). A detailed investigation of this area was made to learn more about the evolution of the Los Angeles basin and the history and nature of movement on the Santa Monica and Whittier fault systems.

This report covers this area of low hills (fig. 2) situated at the northern edge of the Los Angeles basin. These hills and the intervening lowlands comprise a densely populated portion of metropolitan Los Angeles. Los Angeles Civic Center is situated at the southern edge. Although the heavy cultural development hindered geologic mapping, the occasional fresh exposures and almost 100 percent accessibility by automobile were welcome advantages not found in more typical areas with rugged terrain and thick vegetation.

The area is divided into several distinct hilly segments by the flood plains of the Los Angeles River, the Arroyo Seco and some smaller streams. It includes the southeastern tip of the Santa Monica Mountains, the Elysian Park Hills, the western portion of the Repetto Hills and the southern edge of the San Rafael Hills. In addition it includes several smaller features, such as Raymond Hill in the city of Pasadena and Adams Hill in the city of Glendale.

Previous Work

The Los Angeles basin area has been intensively studied by geologists with the state and federal surveys and by the local universities and oil companies. The available reports on the part of this work that pertains to the present study are briefly described in chronologic order below; complete references are given in the bibliography. More complete summaries of earlier work may be found in the papers noted.

1907	Eldridge, G. H., and Arnold, Ralph. Includes geologic maps of Los Angeles City area and Puente Hills.
1931	Hoots, H. W. A study of the geology of the eastern Santa Monica Mountains. Hoots' detailed geologic map includes the northwest corner of the area mapped in detail in the present investigation.
1932	Soper, E. K., and Grant, U. S. IV. Primarily a paleontologic study of the Pliocene rocks in downtown Los Angeles. Includes a geologic map based on exposures which are now covered. A portion of the geology shown on plate 1 accompanying this report has been modified from this map.
1934	Edwards, E. C. Description of Pliocene conglomerates in the Los Angeles basin including data on outcrops in downtown Los Angeles.
1934	Miller, W. J. A study of the basement rocks of the western San Gabriel Mountains including a portion of the northern edge of the area covered in this investigation.
1938	Woodring, W. P. Description of lower Pliocene megafossils from the Los Angeles basin and their inferred environment.
1940	Buwalda, John. Unpublished report on the Raymond basin with a description of the Raymond fault. Includes the northeast corner of the area mapped in detail in this study.
1941	Quarles, Miller, Jr. Master's thesis covering the Montebello and a portion of the Repetto Hills in the southeastern part of the area mapped in the present investigation.
1943	Soper, E. K. Geologic map and brief description of the Los Angeles City oil field and vicinity.
1951	Schoellhamer, J. E., and Woodford, A. O. A study of the basement rocks within and around the Los Angeles basin with emphasis on the buried schist surface beneath the west side of the basin.
1952	Martin, L. A study of Foraminifera from Pliocene rocks exposed in downtown Los Angeles.
1952	Natland, M. L. Doctor's thesis on the Pleistocene and Pliocene foraminiferal sequence in southern California. Includes data on the inferred environment of deposition.
1952	Vandiver, V. W. Sketch map of the Los Angeles area largely west of the Los Angeles River.
1953	Neuerburg, G. J. Description of the geology of the Griffith Park area in the eastern Santa Monica Mountains. Includes the northwest edge of the area studied in the present investigation.
1954	Dudley, P. H., Jr. Master's thesis covering much of the area east of the Los Angeles River mapped in the present investigation.
1954	Gay, T. E., Jr., and Hoffman, S. R. Report on the mineral resources of Los Angeles County. Contains a generalized geologic map and a lengthy bibliography.
1954	Natland, M. L., and Rothwell, W. T., Jr. Description of fossil Foraminifera and sections from the Los Angeles and Ventura regions.
1954	Woodford, A. O., *et al.* Geologic map and description of the Los Angeles basin area. The

map is a compilation of U.S. Geological Survey work and miscellaneous published and unpublished maps.

1957 McCulloh, T. H. Gravity study of the western Los Angeles basin. Shows a steep gradient in gravity along the probable course of the Hollywood fault at the north edge of the basin.

1958 Barbat, W. F. Description of the evolution of the Los Angeles basin and the occurrence of oil.

1958 Sanford, A. R. Doctor's thesis describing the results of a gravity survey of a portion of the Raymond and San Gabriel basins.

1959 Conrey, B. L. Doctor's thesis describing variations in thickness and lithology of the lower Pliocene sediments in the Los Angeles basin.

1960 Sullwold, H. H., Jr. Description of current-direction features and lithology of the Modelo Formation (upper Miocene) exposed on the north flank of the Santa Monica Mountains. Includes important inferences on the environment of deposition.

1965 Yerkes, R. F., *et al.* Summary of geology of the Los Angeles basin principally from work of the U.S. Geological Survey.

Acknowledgments

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Wayne Felts of Texaco Incorporated released information and samples from Texaco and Seaboard Oil Company (merged with Texaco) wells. In addition, Joseph Ernst, Louis Canut, and Arthur Cohn of Texaco offered valuable suggestions on problems in subsurface interpretation. W. T. Rothwell, Jr. and R. L. Brooks of Richfield Oil Corporation identified the Foraminifera collected by the author. W. T. Rothwell, Jr. identified the fish scales, clarified some of the problems in correlation, and demonstrated methods of collecting microfossils in the field. W. H. Holman and O. E. Weser of the Standard Oil Company of California provided some paleontologic data on outcrop samples in the area and explained some of the stratigraphic problems. John H. Van Amringe released data and samples from selected Union Oil Company wells and paleontologic data from Union outcrop samples. Takeo Susuki of the University of California at Los Angeles and J. G. Vedder of the U.S. Geological Survey identified and gave their opinions as to the age of the possible Pliocene megafossils collected from the Highland Park area. During the thesis work the author was supported in large measure by fellowships granted by the Shell Oil Company and the Sunray-Midcontinent Oil Company.

DESCRIPTIVE GEOLOGY

Figure 3 illustrates the general distribution, lithology, and thicknesses of the rock units exposed in the Elysian Park-Repetto Hills area. The sedimentary rock units range in age from middle Miocene to Recent and have a maximum aggregate thickness of 20,000 feet. The principal sedimentary rock units are the Topanga and Puente Formations of middle and late Miocene age and the Fernando Formation of Pliocene age. These units change abruptly in thickness and lithology across major faults. Extremely rapid facies changes also occur within individual fault blocks. These sedimentary rocks rest on Mesozoic plutonic rocks consisting of quartz diorite and granodiorite and, in the subsurface, on the Santa Monica Slate(?) of Triassic(?) and Jurassic age.

The stratigraphic columns in this report were constructed from the original geologic map (Lamar, 1961, pl. 1), which has a scale of 1 inch = 1000 feet.

Pre-Upper Cretaceous Basement Rocks

SANTA MONICA SLATE

The Santa Monica Slate is exposed in the central Santa Monica Mountains, where it was named by Hoots (1931, p. 88). Pelecypod fragments which indicate a Late Jurassic age have been reported from one fossil locality within this unit (Silberling *et al.*, 1961; Imlay, 1963).

The Santa Monica Slate forms brown-stained, gray-to-black intensely fractured and weathered exposures. The stain is a thin film of limonite derived from weathering of pyrite. In the area described by Neuerburg (1951, p. 14), the Santa Monica Slate, before metamorphism, consisted of approximately 95 percent black shale or siltstone and fine- to medium-grained graywacke. Impure quartz sandstone, feldspathic sandstone, and rare quartzite pebble conglomerate comprised about 5 percent of the unit. In the eastern portion of its exposure in the Santa Monica Mountains, the slate is metamorphosed to schist and phyllite at and near its contact with quartz diorite (Nichols pluton of Neuerburg, 1951).

The Santa Monica Slate is not exposed in the area mapped in the present study. Lithologically similar rocks that were reached in three wells drilled for oil in the area have been correlated with the Santa Monica Slate. Data on these wells are summarized in the listing that appears at the top of p. 11. The well numbers refer to the listing in table 2 (p. 41–42) and the designation on plate 1.

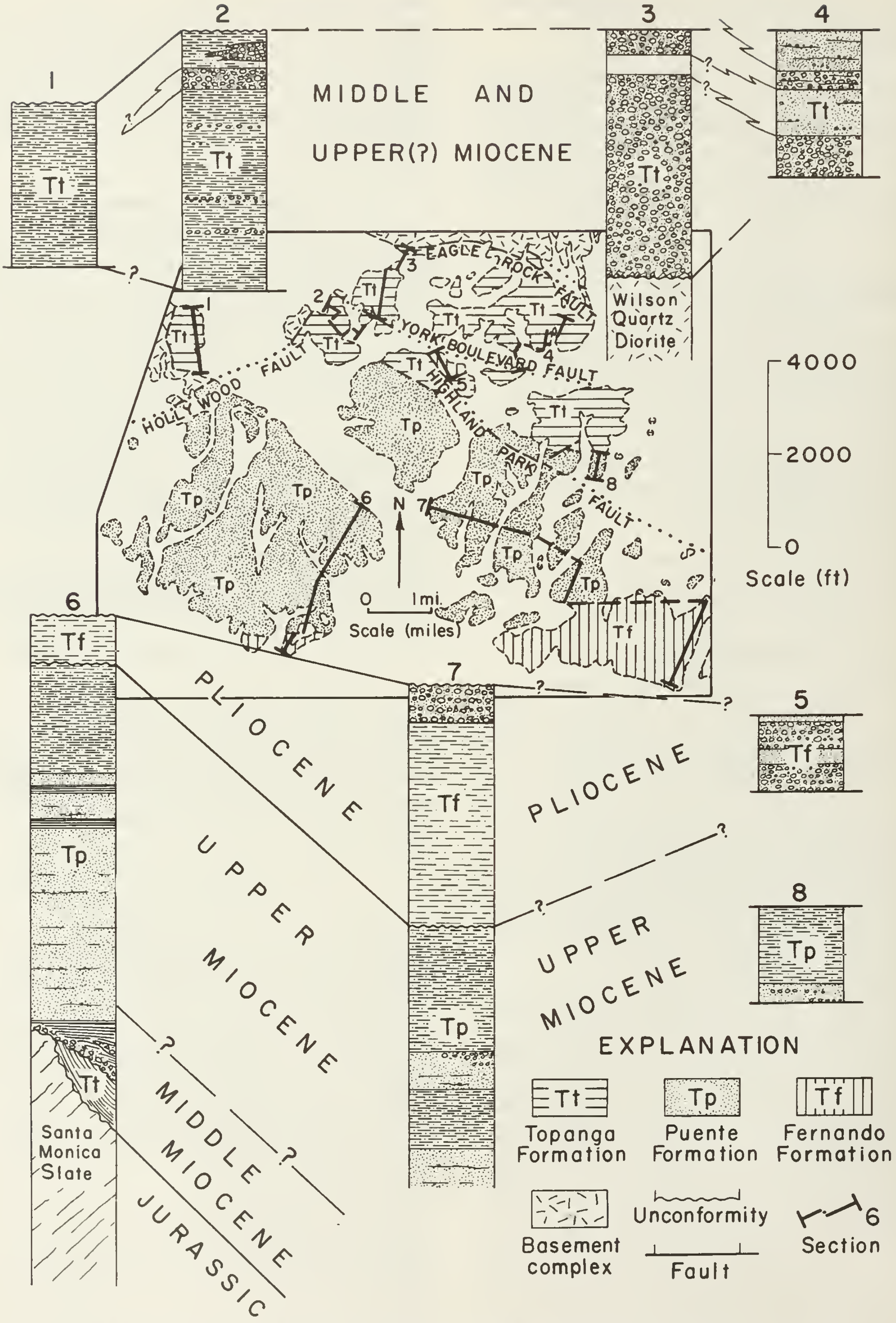

Figure 3. Generalized Columnar Sections. The Santa Monica Slate and Topanga Formations shown in column 6 are present in the subsurface only.

Well No.	Well	Depth to Top of Basement Rocks (feet)	Depth of Sample (feet)	Kind of Rock
19	Seaboard Oil Company (Park No. 1)	1370	2006	Slate, foliated, contains angular quartz grains and biotite
22	Seaboard Oil Company (Core Hole No. 5)	2704	2713–2723	Cordierite (?) spotted slate
			2723–2732	Impure quartzite (Data from Schoellhamer and Woodford (1951))
8	Continental Oil Company (Monterey Park Unit No. 1-1)	3935	Unknown	Hornblende-biotite phyllite

PLUTONIC IGNEOUS ROCKS

Quartz diorite and granodiorite are exposed in the San Rafael Hills and eastern Santa Monica Mountains in the northern part of the area studied. These rocks have been divided into units whose mineral compositions are shown in table 1. The relative age of the plutonic rocks exposed in the eastern Santa Monica Mountains (Feliz Granodiorite and Vermont Quartz Diorite) and San Rafael Hills (Wilson Quartz Diorite and granodiorite dikes) is unknown.

Feliz Granodiorite

The Feliz Granodiorite, named and described by Neuerburg (1953, p. 12–14), is exposed at the southeastern end of the Santa Monica Mountains. The Feliz Granodiorite is deeply weathered, fairly soft, and dull gray to light brown. The rock is medium-grained, hypautomorphic, and equigranular; the structure is massive.

Vermont Quartz Diorite

The Vermont Quartz Diorite was named and described by Neuerburg (1953, p. 9–11) and is exposed in Griffith Park at the northwest corner of the area mapped in detail in the present study. The Vermont Quartz Diorite consists of a fine-grained chilled border zone and a medium-grained central zone. The border zone occurs along the contact with metabasalt and metagabbro to the west (Neuerburg, 1953) and the Feliz Granodiorite to the east. A very faint flow banding in the border zone of the Vermont Quartz Diorite appears to be parallel to the contact with the Feliz Granodiorite. These relations suggest that the Vermont Quartz Diorite is intrusive into the Feliz Granodiorite.

In most exposures the central zone is deeply weathered, crumbles easily, and is rust brown. The rock of the border zone appears black to dark brown due to the dark minerals and stained feldspars, and is very soft. The texture of the border zone is equigranular and hypautomorphic granular. The massive portion is medium-grained, hypautomorphic and equigranular.

Wilson Quartz Diorite

The Wilson Quartz Diorite was originally named the Mount Wilson Quartz Diorite by Miller (1926) and was subsequently referred to as the Wilson Diorite (Miller, 1934, p. 34; Miller, 1946, p. 468–469) and Wilson Quartz Diorite (Miller, 1946, table 4). In Forest Lawn Memorial Park and the western San Rafael Hills, the Wilson Quartz Diorite is massive to poorly foliated. To the east, in the San Rafael Hills and in the small exposure north of the York Boulevard

Table 1. Mineral Composition of Plutonic Igneous Rocks.*

Rock unit, map symbol in parentheses	Quartz	Plagioclase, percent Anorthosite in parentheses	Orthoclase	Microcline	Biotite	Hornblende
Feliz Granodiorite (fq)	40	50(15)	—	8	2	—
Vermont Quartz Diorite (vqd)	20–30	45–75(40)	5–20	—	4–5	1–2
Wilson Quartz Diorite, massive unit (wqm)	7	60(50)	—	—	3	30
Wilson Quartz Diorite, gneissoid unit (wqg)	15–20	70–75(43)	—	—	5–10	5
Granodiorite	30	30(20)	—	35	4	—

*In percent by volume for rocks exposed in the mapped area. Minor accessory and secondary minerals are not included.

fault, this rock is well-foliated and granulated. Based on these differences in texture the Wilson Quartz Diorite has been divided into massive and gneissoid units.

The massive unit of the Wilson Quartz Diorite is deeply weathered, and friable. It is light gray to rust brown; the texture is medium-grained, equigranular, and hypautomorphic granular. In the San Rafael Hills the massive unit of the Wilson Quartz Diorite grades into a gneissoid quartz diorite. The contact and bands of massive quartz diorite within the gneissoid part are parallel to the gneissic banding. Fresh exposures of the gneissoid quartz diorite are present in the Arroyo Seco where the rock is medium gray. In other areas the rock is deeply weathered, soft, and light brown. The typical gneissoid quartz diorite consists of plagioclase feldspar which is elongate parallel to the foliation and set in a matrix of fine-grained hornblende, quartz, and biotite. The distinct gneissic banding results from the parallel orientation of the feldspar augen, biotite tablets and hornblende prisms. The light and dark minerals are only rarely concentrated into distinct bands.

A sample of Wilson Quartz Diorite collected from Mount Wilson has been determined to be 122 million years old (Jaffe *et al.*, 1959, p. 85) or Early Cretaceous on the time scale of Kulp (1961).

Granodiorite

Small irregular dikes of granodiorite intrude the Wilson Quartz Diorite in the San Rafael Hills. These dikes were not mapped. Miller (1934, p. 37) believed these were late magmatic offshoots of the Lowe Granodiorite magma (Miller, 1934, p. 41). In exposures in cuts along the Colorado Freeway and in the Arroyo Seco the granodiorite is light gray and hard. West of the Arroyo Seco the rock is deeply weathered, easily crumbled and light brown to chalky white. The texture is medium- to fine-grained, equigranular, and hypautomorphic granular. The mineral composition of the one specimen studied is that of a normal adamellite rather than granodiorite. Its composition is well within the range for the Lowe Granodiorite given by Miller (1934, p. 43), which, according to him, averages a silicic granodiorite.

Miocene Series

NOMENCLATURE

A thick section of middle and upper Miocene sedimentary and volcanic rocks rests on lower Miocene marine sediments (Vacqueros Formation), non-marine sediments (Sespe Formation) and older rocks, in the Los Angeles basin area (Woodford *et al.*, 1954, p.

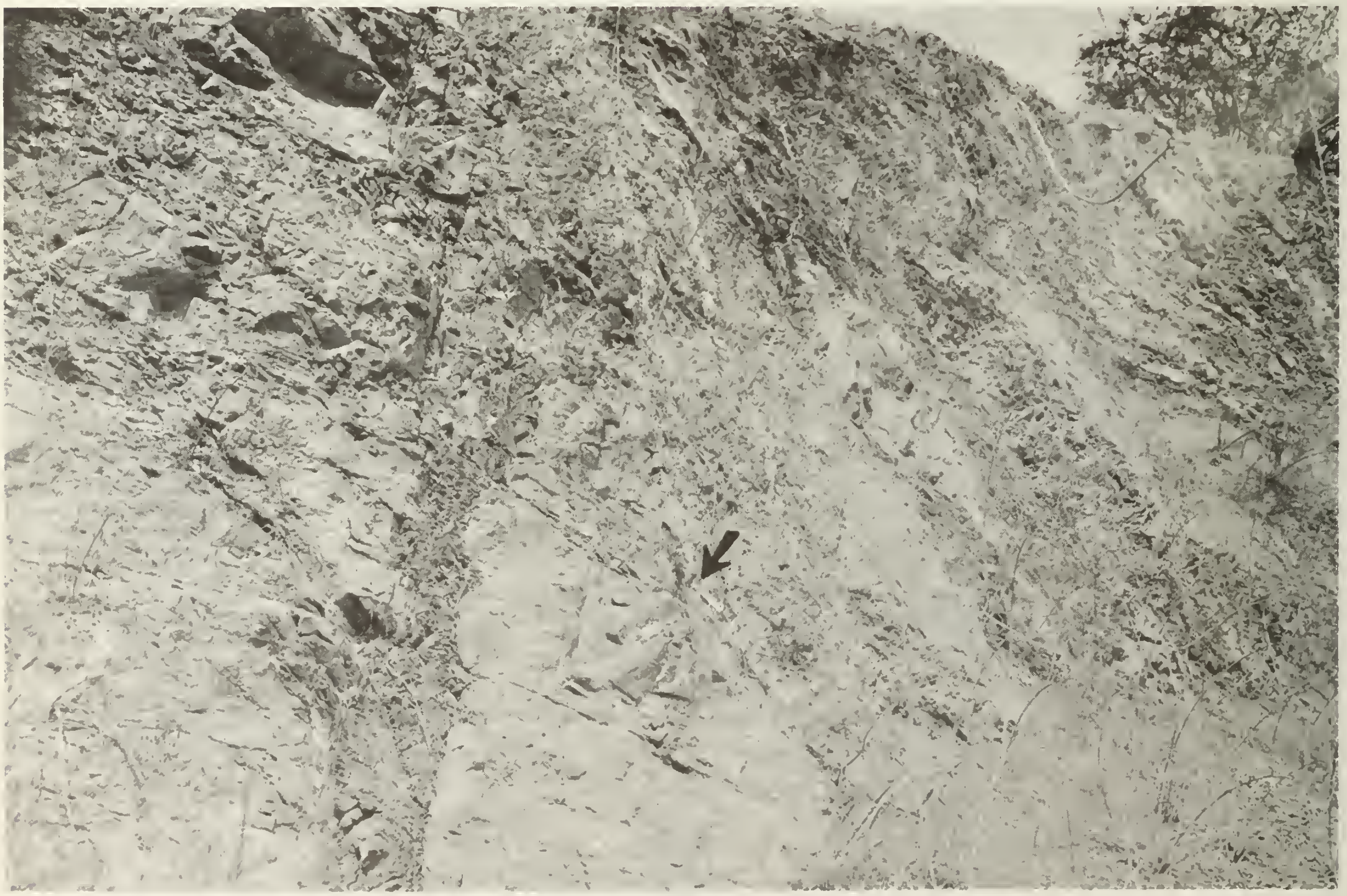

Figure 4. Wilson Quartz Diorite. In an exposure in Forest Lawn, the diorite is faulted against siltstone of the Topanga Formation. Hammer (arrow) indicates scale.

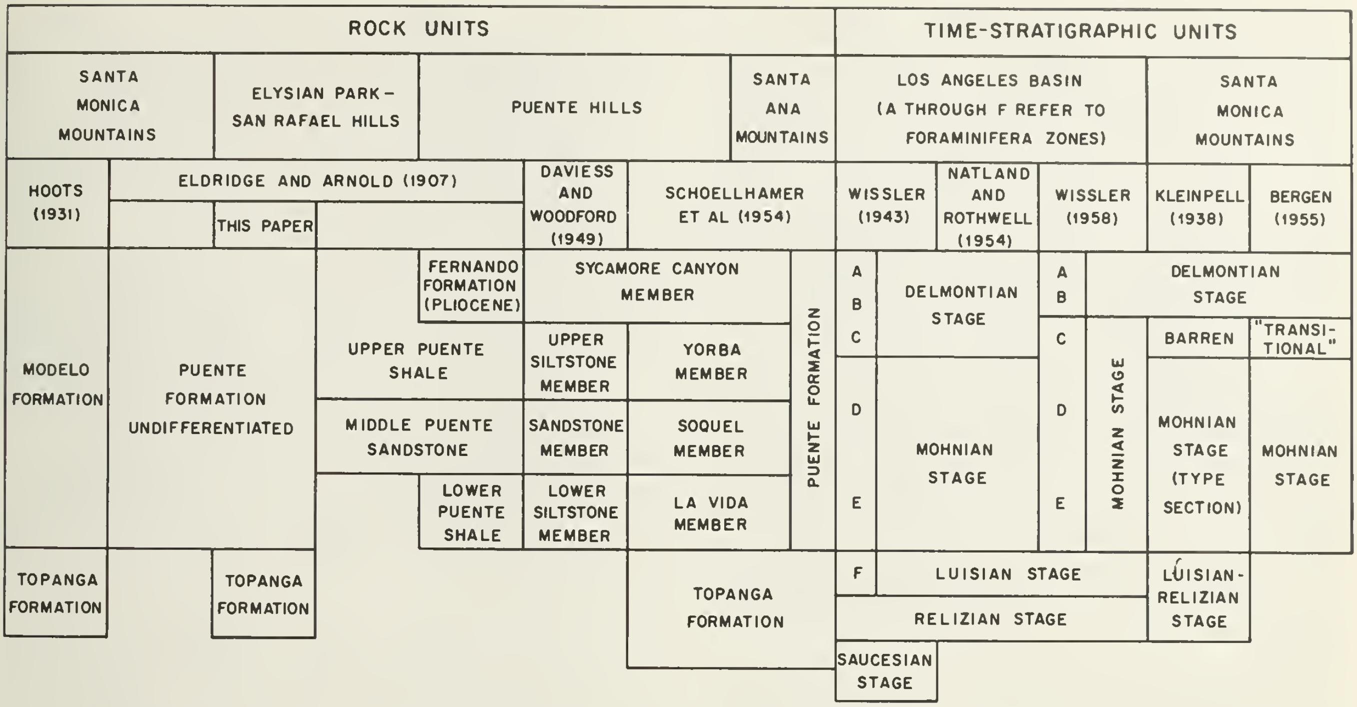

Figure 5. Nomenclature of Miocene Rock and Biostratigraphic Units. The chart also correlates the rock and time-stratigraphic units found in the Los Angeles basin area. The lower portion of the Fernando Formation (Pliocene) of Eldridge and Arnold (1907) was subsequently determined to be late Miocene, and Krueger (1936) named it the Sycamore Canyon Formation.

68). Sedimentary rocks older than middle Miocene do not crop out in the Elysian Park-Repetto Hills area. The stages defined by Kleinpell (1938) on the basis of Foraminifera and local formation names have been applied to these middle and upper Miocene rocks. Figure 5 summarizes the nomenclature used in this paper and by previous workers.

Kew (1923, p. 416) applied the name "Topanga formation" in the Santa Monica Mountains to "those rocks lying below the Modelo formation (upper Miocene) and above the Vacqueros formation (lower Miocene) and containing a fauna commonly referred to as the *Turritella ocoyana* fauna, which is probably equivalent in age to the 'Temblor fauna' of the San Joaquin Valley." Following Kew's definition, most of the rocks in the northern and eastern part of the Los Angeles basin area containing lower and middle Miocene fossils (including Foraminifera of Kleinpell's Saucesian, Relizian, and Luisian Stages) and overlain uncomformably by the Puente Formation (equivalent to Modelo Formation of the Santa Monica Mountains) have been called the Topanga Formation (Woodford *et al.*, 1954).

The upper Miocene rocks in the Puente Hills were originally described and named the Puente Formation by Eldridge and Arnold (1907, p. 103–105). Eldridge and Arnold divided the Puente Formation into the lower Puente shale, the Puente sandstone, and the upper Puente shale. In the northwest Puente Hills, interbedded conglomerate and siltstone originally mapped by Eldrige and Arnold (1907) as Fernando Formation (Pliocene) were determined to be upper Miocene and were named the Sycamore Canyon Formation by Krueger (1936). Daviess and Woodford (1949) redefined the Sycamore Canyon as the uppermost member of the Puente Formation. Recently, Schoellhamer *et al.* (1954) and Durham and Yerkes (1964) have extended the use of the name "Sycamore Canyon member" to upper Puente strata in other parts of the Puente Hills and in the northern Santa Ana Mountains. Schoellhamer *et al.* (1954) also named and redefined Eldridge and Arnold's unnamed members of the Puente Formation, as shown in figure 5. These names have been applied to upper Miocene rocks exposed in the Santa Ana Mountains and Puente Hills (Schoellhamer *et al.*, 1954; Vedder *et al.*, 1957; Durham and Yerkes, 1964).

Eldridge and Arnold (1907, p. 145–150) also mapped the Puente sandstone and upper Puente shale in a portion of the area described in this report. In this area, which appears on a regional geologic map of the Los Angeles basin area, Woodford *et al.* (1954) have applied the member names of the Puente Formation defined by Schoellhamer *et al.* (1954) to these rocks. Because of the complex geology, the present author was unable to apply the Puente Formation members recognized by Schoellhamer *et al.* (1954), and new local member names were not defined.

Eldridge and Arnold (1907, p. 146) did not map, but applied the name Puente Formation to, ". . . strata along the flanks of the Santa Monica Mountains west of Sherman. . . ." (Sherman is shown on Eldridge and Arnold's map east of what is now Beverly Hills.) Hoots (1931) included the upper Miocene rocks in the eastern Santa Monica Mountains in the Modelo Formation. The Modelo Formation was originally named and described by Eldrige and Arnold (1907) p. 17–19) in the Santa Clara Valley area. In this area the Modelo Formation has been redefined by Kew (1924, p. 55–69) and more recently by Winterer and Durham (1962, p. 286–287). The type section of Kleinpell's (1938, p. 127) Mohnian Stage is the lower part of the Modelo Formation exposed near Mohn Springs in the Santa Monica Mountains. The Modelo Formation (as delimited by Hoots, 1931, p. 102) in the Santa Monica Mountains rests unconformably on rocks of the Topanga Formation, which contain Foraminifera representative of Kleinpell's Luisian and Relizian Stages. In its type area in the Santa Clara Valley area or eastern Ventura basin, the lower part of the Modelo contains Relizian and Luisian Foraminifera (Kleinpell, 1938, p. 166). The significance of the boundary between Kleinpell's Mohnian and Luisian Stages and its relationship to the unconformity between the Puente (Modelo) and Topanga Formations in the Elysian Park-Repetto Hills area is discussed following a description of the Topanga and Puente Formations.

Difficulties have arisen in efforts to locate the boundary between Kleinpell's Mohnian and Delmontian Stages in the Los Angeles basin. These difficulties may arise from the original definitions, because, in its type area, the Mohnian ". . . is separated from the foraminiferal Delmontian Stage above by nonforaminiferal diatomaceous shale and sandstone in a conformable sequence" (Kleinpell, 1938, p. 127). In its type area, "The base of the Delmontian Stage is here taken as the horizon of marked lithologic change . . ." (Kleinpell, 1938, p. 131). Bergen (1955) restudied the Mohnian-Delmontian boundary near the type area for the Mohnian. He found a transitional foraminiferal fauna different from and with nearly equal affinities to both the Delmontian and Mohnian Stages in beds equivalent to the nonforaminiferal diatomaceous shale and sandstone overlying Kleinpell's type Mohnian Stage. In his foraminiferal studies of the Los Angeles basin, Wissler (1943, p. 218) originally placed his Division C in the lower Delmontian and subsequently decided that it is upper Mohnian (Wissler, 1958, p. 60). Rothwell (personal communication, 1960) cannot justify placing strata equivalent to Wissler's Division C in either the Delmontian or Mohnian Stages, but has observed the most distinct faunal change in the upper Miocene sequence in the Los Angeles basin at the top of Division D, and, therefore, arbitrarily chooses this point as the Delmontian-Mohnian contact and places Division C in the Delmontian (Natland and Rothwell, 1954, p. 40). Apparently Division C occupies a position analogous to Bergen's (1955) transitional zone.

DIABASE

Two small intrusive masses of diabase occur in the mapped area at the eastern end of the Santa Monica Mountains. The diabase appears to be intruded along the fault between the Topanga Formation and the Feliz Granodiorite. No other shallow intrusive or extrusive basaltic rocks are exposed in the mapped area. It is probable that the diabase is the same age as the extensive middle Miocene volcanic and shallow intrusive rocks exposed throughout the Santa Monica Mountains (Hoots, 1931; Durrell, 1954). The rock is deeply weathered brown to red-brown. The texture

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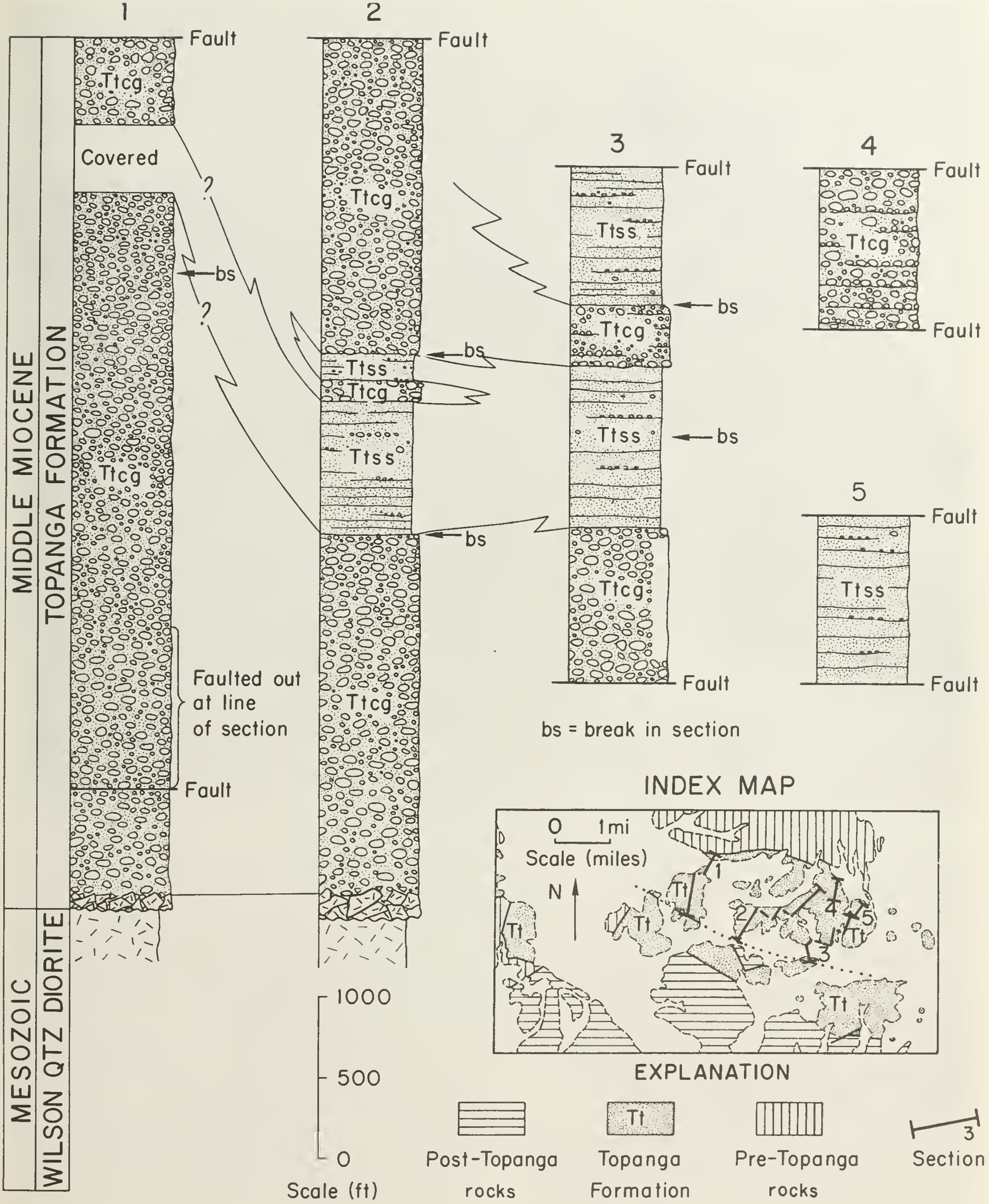
Figure 6. Columnar Sections of Topanga Formation North of York Boulevard Fault (right).

Ttcg: Conglomerate and conglomeratic sandstone; very light gray or brown to reddish brown fresh and weathered clasts estimated to average 30 percent of rock with a maximum of 90 percent in some beds; clasts poorly sorted and subrounded to subangular; clasts average about two inches in diameter and the largest clasts observed are three feet in diameter. The clasts average 60 percent leucocratic plutonic rock and 40 percent dark biotite-rich gneiss and schist. The larger clasts consist of a higher proportion of schist and gneiss than the smaller clasts. Hard and well-cemented; natural outcrops commonly weather fairly smooth and rounded; grains forming matrix medium to very coarse, angular to subangular and poorly sorted. In the west (sections 1 and 2) this unit is massive; bedding is shown by crude alternation of sandy layers and pebble-rich layers averaging six inches thick, alignment of long dimension of clasts, and indistinct biotite-rich layers in the conglomeratic sandstone beds. To the east (sections 3 and 4) this unit becomes well bedded; beds ½ inch to four feet thick, average six inches; bedding irregular and load casts at the base of the thicker beds; some thinly laminated (average ¼ inch thick) biotite-rich layers; beds usually well-graded from coarse-grained sandstone or conglomeratic sandstone at the base to medium-grained sandstone at the top. Breccia consisting of angular blocks of quartz diorite and granodiorite up to 15 feet in diameter is exposed at the base of sections 1 and 2. Matrix very poorly sorted sandstone which contains abundant fragments of dark minerals. Because of lithology and small percentage of matrix, and deep weathering, this breccia has the appearance of weathered and fractured basement rock.

Ttss: Sandstone, fine- to very coarse-grained, predominantly coarse-grained, grades into adjacent conglomerate and contains similar beds of conglomerate up to 10 feet thick, also scattered erratic clasts up to three feet in diameter; usually medium to light brown, glistening white to light gray in eastern part of area near the Arroyo Seco; layers with up to 35 percent carbonized wood fragments and coal seams up to one inch thick; poorly sorted and the grains are angular to subangular; well bedded with smooth bedding planes, thin (1/16 inch thick or less) partings between bedding surfaces; coarse sandstone beds average two inches thick, maximum thickness 10 feet, bedding within thick beds commonly indicated by biotite-rich layers and by graded lamina ¼ to three inches thick of very coarse- to medium-grained sandstone; rare nodules and layers of gray hard calcareous sandstone up to three inches thick; finer-grained, more thinly bedded and contains more coal and carbonized wood to the east near the Arroyo Seco; usually well-cemented, softer and less well-cemented along the Arroyo Seco; thin-bedded fine- to medium-grained sandstone occasionally cross-bedded; groove- and loadcast lineations at the base of some of the coarser-grained thicker sandstone beds; individual beds commonly graded from coarse at the bottom to fine at the top, carbonized wood fragments up to ¼ inch in diameter usually concentrated in the upper part of graded sandstone beds. Some slabs and clasts of fine-grained sandstone were observed within thick coarse-grained conglomeratic sandstone beds.

Note: The conglomerate shown on section 4 grades into the sandstone shown on section 5.


1
2
3
4
5
MIDDLE MIOCENE
TOPANGA FORMATION
MESOZOIC
WILSON QTZ DIORITE
Fault
Ttcg
Covered
?
bs
Ttss
Faulted out at line of section
bs = break in section
1000
500
0
Scale (ft)
INDEX MAP
0 1mi
Scale (miles)
N
Tt
EXPLANATION
Post-Topanga rocks
Topanga Formation
Pre-Topanga rocks
Section

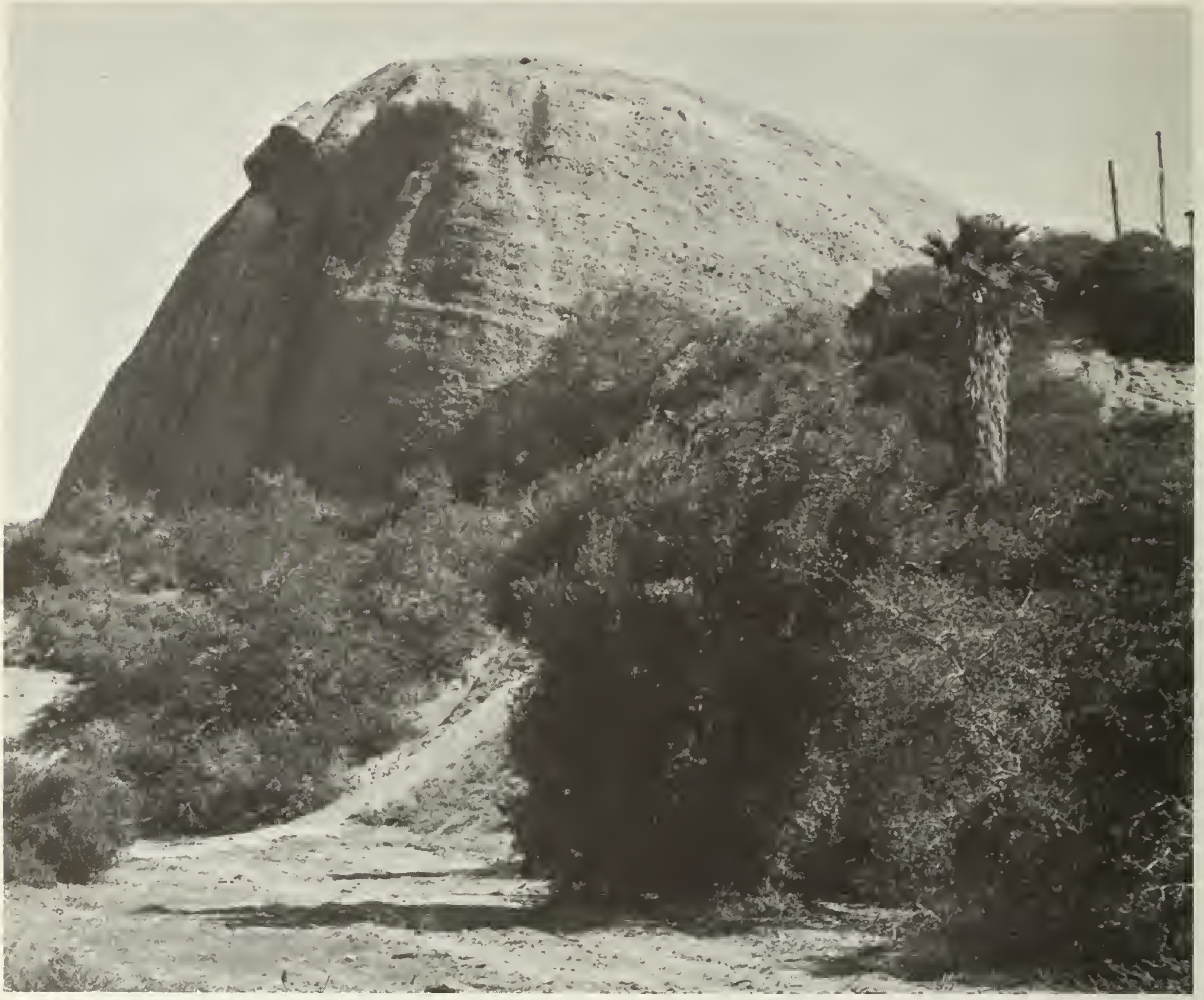


Figure 7. Topanga Formation Conglomerate. The exposure is known locally as "Eagle Rock."

is fine-grained, equigranular and subophitic. Feldspar laths and possible altered olivine were observed with a hand lens.

TOPANGA FORMATION

Interbedded, and in places interfingered, conglomerate sandstone and very hard brown siliceous shale and siltstone exposed in the northern part of the area are included in the Topanga Formation. The Topanga Formation north of the York Boulevard fault is distinctly different from most of the Topanga exposed in outcrops south of the fault.

North of York Boulevard Fault

A maximum of 5,500 feet of interbedded massive conglomerate and coarse-grained, well-bedded sandstone is exposed north of the York Boulevard fault. The variations in thickness and lithology are illustrated in figure 6. Middle Miocene fish scales were found in this sequence of rocks at two localities in coarse-grained, well-bedded sandstone. The age of this sequence of rocks may also be estimated through comparisons with rocks in adjacent areas.

Massive conglomerate and conglomeratic sandstone rest on middle Miocene (Eaton, 1957, p. 112; Hardey, 1958, p. 12; Neuerburg, 1953, p. 14) volcanic rocks in the eastern Santa Monica Mountains. In the Cahuenga Peak area in the eastern Santa Monica Mountains, these rocks were mapped as Topanga Formation (middle Miocene) and described by Hoots (1931, p. 97) as ". . . a mass of rounded to subangular boulders and cobbles embedded in a soft matrix of coarse arkosic sandstone." Subsequently, Neuerburg (1953, p. 20) studied the same area and concluded that most of the rocks east of Cahuenga Pass and northwest of the "basaltic series" of the Topanga Formation are Cretaceous (?) in age. He states that ". . . the lower member of the 'basalt series' (rests) on conglomerate of the lower part of the conformable Cahuenga formation series . . ." Neuerburg's geologic map indicates that this relation exists only in the south-central part of this area east of Brush Canyon; in the rest of the area the contact is shown as a fault. E. L. Winterer (personal communication in Dudley, 1954, p. 25) found graded beds which indicate that the Cahuenga Beds of Neuerburg (1953) overlie some of the Topanga Formation. W. T. Rothwell, Jr., of Richfield Oil Corporation, identified fish scales collected southwest of Cahuenga Peak (U.C.L.A. locality 2500 on Neuerburg's map) which he compared with a herring scale (*Xyne* sp. 293) from the lower "Topanga" Formation in the San Joaquin Hills, Orange County and from the lower Relizian shale in Cuyama Valley, Santa Barbara County (Neuerburg, 1953, p. 20). Neuerburg rejected this evidence, although as outlined above the stratigraphic relations in this admittedly structurally complex area suggest a middle Miocene age for the conglomerate in the Cahuenga Peak area.

As described by Hoots (1931, p. 97) and Neuerburg (1953, p. 6–7, 18–20) and observed by the author, the conglomerate and conglomeratic sandstone in the Cahuenga Peak area are lithologically similar to the rocks exposed north of the York Boulevard fault. It is concluded that the rocks north of the York Boulevard fault are also no older than middle Miocene. In this area these strata rest on basement rocks rather than middle Miocene volcanic rocks as they do in the eastern Santa Monica Mountains. Except for the small intrusive masses of diabase in the easternmost Santa Monica Mountains, no shallow intrusive or extrusive igneous rocks were observed in the thick sequence of Miocene rocks exposed in the Elysian Park-Repetto Hills area.

The strata lying beneath the fossiliferous Pliocene rocks on Raymond Hill and in the upper part of the section exposed to the west are unlike any of the Pliocene rocks exposed in the mapped area. This lack of lithologic similarity and the available paleontologic data suggest that these rocks are pre-Pliocene in age. It is possible that a portion of the upper part of this

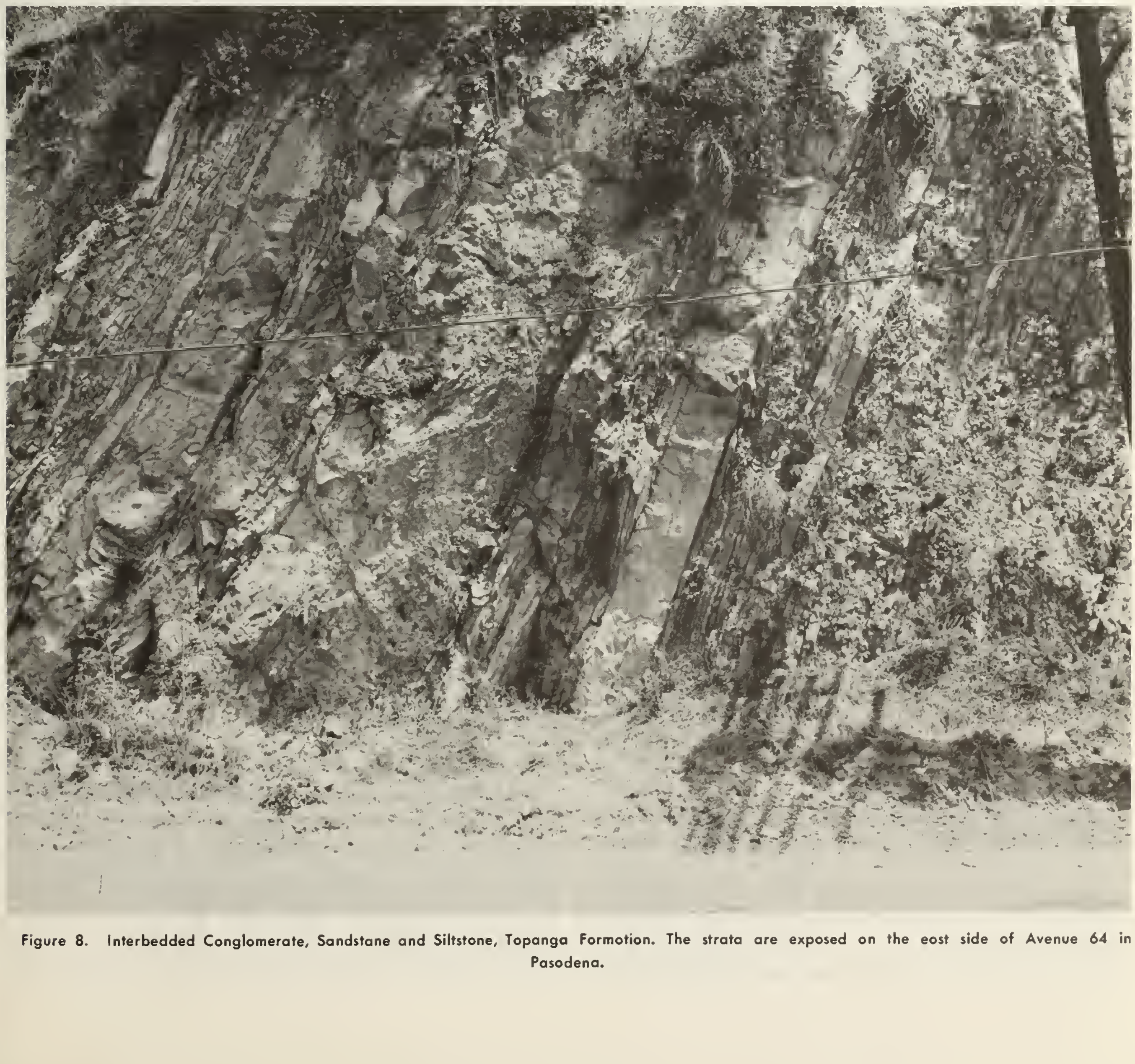


Figure 8. Interbedded Conglomerate, Sandstone and Siltstone, Topanga Formation. The strata are exposed on the east side of Avenue 64 in Pasadena.

FISH GENERA	TOPANGA FORMATION																PUENTE FORMATION								David (1943)					W. T. Rothwell, Jr. (personal comm. 1960)		
	North of York Boulevard fault				South of York Boulevard fault												North of Highland Park fault				South of Highland Park fault				Horizontal			Vertical				
	34-24	34-8	33-10	33-9	18-34	18-4	18-9	31-3	27-13	27-14	27-18	28-26	28-18	1-17	1-16	28-24	25-23	25-20	28-22	28-21	30-20	4-5	3-16	27-10	Neritic	Pelagic	Abyssal-Bathypelagic	Free swimming	Bottom fishes	Shallow	Neritic	Oceanic-Bathyal
Decapterus														1			1								+	+	-	+	-			
Etringus and Etrumeus	1	1			2									1	1	1	1	2		2			2		+	?	-	+	-		+	
Ganolytes		1	1	1	1		1	2				1			1	2		1		2	1				+	?	-	+	-			
Lompoquia									1	1			1	1			2	1	1			1		1	+	-	-	+	+			
Plectrites	1														1	1	1								+	-	-	-	+	+		
Pneumatophorous														1			2	1	1	1					+	+	-	+	+			
Sarda				1										1											-	+	-	+	-			
Scomber											1		1				1								+	+	-	-	-			
Alosa or Xyne	1					1	1		1	1	1		1	1								1	2		+	+	-	+	-			+
Cynoscion																		1							+	+	-	+	-			+
Scomberesox																1									+	+	-	+	-			+
Cololabis			1																						Close to surface in large schools (Barnhart, 1936, p. 23)							
Paralabrax										1															Around kelp beds, on rocky bottom in shallow water in sandy bays (Barnhart, 1936, p. 72)							
Syngnathus																	1		1						Along open shores and in bays (Barnhart, 1936, p. 34)							

Figure 9. Ecologic Data on Fish Genera in Miocene Rocks. The numbers across the top refer to fossil localities. The numbers within the squares are the occurrences of species from each genera. The plus signs indicate present occurrence within the environment shown.

sequence of Topanga rocks is Mohnian or Delmontian (late Miocene) in age.

The Topanga Formation north of the York Boulevard fault grades from almost entirely massive conglomerate in the northwest to approximately equal parts of well-bedded conglomerate and coarse, well-bedded sandstone and conglomeratic sandstone in the southeast. The thickness of the conglomerate unit at the base of the section thins to the southeast. A few cross-bedding and current-lineation measurements in the well-bedded sandstone indicate a current direction of S 18° E (Lamar, 1961, pl. I), and thus that the Topanga Formation north of the York Boulevard fault had a source to the north-northwest.

The living relatives of the fish whose scales were found in the Topanga Formation north of the York Boulevard fault live in a neritic (continental shelf) and, less commonly, in the pelagic (open ocean) environment as indicated in figure 9. This suggests that most of the coarse-grained sandstone accumulated in the open ocean rather than in a littoral or shallow water environment. No fossils were found in the conglomerate west of the Arroyo Seco, so it is possible that much of the conglomerate in the western part of the area, close to the inferred source area, accumulated in a fluvial environment. But considering the rarity of fossils in the well-bedded coarse-grained sandstone, fossils would not be expected to endure under the more severe conditions of deposition implied by the texture of the conglomerate. The lack of red color which is characteristic of the nonmarine Sespe Formation underlying the Topanga Formation in other parts of the Los Angeles basin also suggests deposition of the conglomerate in a marine rather than nonmarine fluvial environment.

The well-bedded sandstone and conglomerate in the eastern part of the area show the following features considered by Kuenen and Carozzi (1953) and Sullwold (1960) to be characteristics of sediments deposited by turbidity currents: (1) graded bedding, (2) load casts and load deformation lineations, (3) groove cast lineations, (4) poor sorting, (5) regular bedding or even continuity of individual sandstone and conglomerate beds, (6) absence of shallow water features such as oscillation ripple marks, coarse cross-bedding, clean, well-sorted sand, desiccation features, and layers of mollusk shells, (7) interbedding of coarse- and fine-grained sandstone rhythmically or with random thicknesses, (8) sharp basal contacts of the sandstone and conglomerate beds, (9) slabs and chips of fine-grained sandstone within coarse, thick sandstone beds, and (10) beds with coarsest grains or largest clasts usually the thickest in any one locality. In contrast, the thick section of massive conglomerate in the northwest displays none of the bedding features such as grading and load casts typical of turbidity current deposition. The very poor sorting and angular to subangular clasts and grains indicate rapid deposition close to a rugged source area of basement rock. It is inferred that the massive conglomerate accumulated as a submarine talus slope adjacent to the source; because of oversteepening with deposition, some of the material slid farther down the slope into deeper water and formed turbidity flows which are reflected in the texture of the rocks to the southeast.

South of York Boulevard Fault

The structure and stratigraphy of the rocks between the York Boulevard fault and the definite upper Miocene Puente Formation to the south are extremely complicated. The variations in thickness and lithology are illustrated in figure 11. On Adams Hill, east of Forest Lawn Memorial Park, massive conglomerate similar to the Topanga conglomerate north of the York Boulevard fault is interfingered with thin-bedded hard brown siltstone and sandstone. Foraminifera and fish scales representative of the upper part of Kleinpell's Luisian Stage have been found in the siltstone and sandstone. According to W. T. Rothwell (personal communication, 1960), the fauna from locality 18-9 in this area is younger than the type Topanga Formation of Hoots (1931).

West of Forest Lawn a Luisian Foraminifera fauna has been found (fossil locality no. 1) in shale from a shallow test hole along Glendale Boulevard. West of the Los Angeles River at the eastern end of the Santa Monica Mountains fish scales of probable Mohnian age were found in thin-bedded siltstone and sandstone, at localities 1-16 and 1-17. W. H. Holman also studied several samples from this same area in the eastern Santa Monica Mountains and found that most of the localities yielded Foraminifera representative of Kleinpell's Mohnian Stage. A few of the localities overlying or in approximately the same stratigraphic position as some of the Mohnian samples contained faunas with definite Luisian affinities and would have been determined as upper Luisian if their stratigraphic position relative to the Mohnian localities had not been known. Therefore, W. H. Holman concluded that these rocks at the eastern end of the Santa Monica Mountains are very earliest Mohnian to Mohnian-Luisian transitional. It should be noted that fossil locality number 9, on which Hoots (1931) apparently based his assignment of a Mohnian age to the rocks in the eastern Santa Monica Mountains and their correlation with the Modelo Formation, is located in Puente (Modelo) strata south of the Hollywood fault.

The thin-bedded sandstone and siltstone exposed on Adams Hill and in the fault block at the east end of the Santa Monica Mountains are lithologically similar, although the sequence on Adams Hill contains more sandstone near the interfingering masses of conglomerate. Conglomerate similar to that exposed on Adams Hill is exposed near the top of the sequence at the east end of the Santa Monica Mountains close to the fault contact with quartz diorite. Because of the nature of the exposure, it is not clear whether this conglomerate is interfingered with the finer-grained rocks or is part of a sliver along the fault which forms the contact between the Topanga Formation and Vermont Quartz Diorite.

Thin-bedded hard brown siltstone and sandstone similar to that occurring at the eastern end of the Santa Monica Mountains and on Adams Hill also occur in the east-central portion of the area. With the excep-

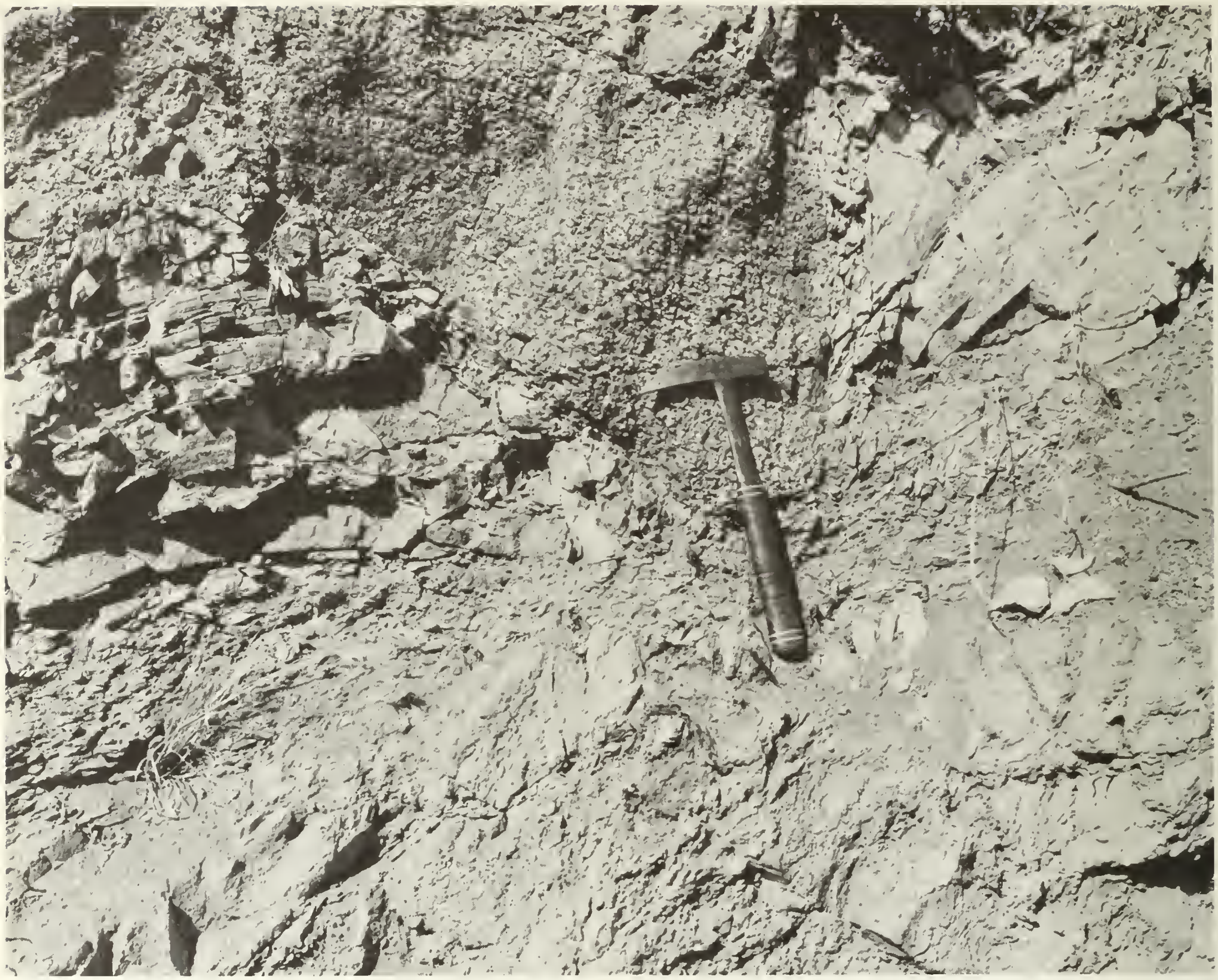


Figure 10. Boulder of Quartz Diorite, Topanga Formation. The boulder occurs in thin-bedded siltstone near an interfingering contact, on Adams Hill in Glendale.

Figure 11. Columnar Sections of Topanga Formation South of York Boulevard Fault (right).

Ttsl: Interbedded siltstone, sandstone and shale; dark brown to gray weathering; the dark brown color of weathered surfaces characteristically has the appearance of a surface coating. Rhythmically bedded in layers averaging two inches thick. Very hard and well-cemented; blocky weathering. Siltstone is light gray to dark brown, most commonly medium brown. Layers of dark brown sandstone are up to three feet thick. Sandstone is fine- to very coarse-grained and poorly sorted. Sandstone is commonly finely laminated and graded. Loadcasts occur at base of some sandstone beds. Contains layers of massive orange-brown limestone as much as two feet thick and beds of very hard creamy white tuff and tuffaceous sandstone. Very hard siliceous shale, which is red-brown weathered and light gray when fresh, occur. Light gray, platy shale and siltstone are more common near the base of section 4 and in the Mount Washington area, west of the Highland Park fault. Fish scales are common on bedding planes. These rocks interfinger with conglomerate (Ttcg) and contain more sandstone near the conglomerate bodies.

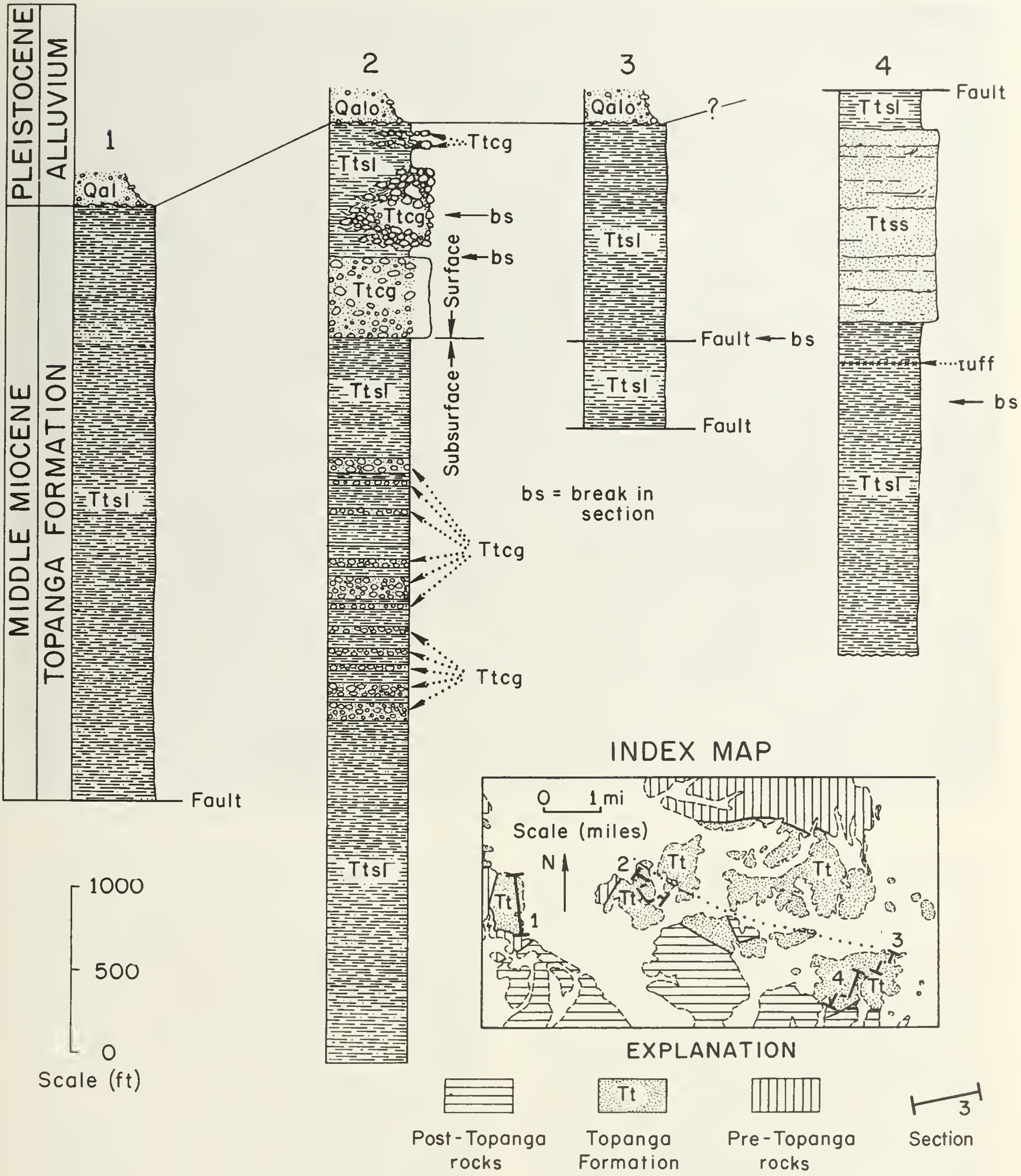
Ttcg: Conglomerate and conglomeratic sandstone; very light gray or brown to reddish brown fresh and weathered; massive and poorly sorted. Matrix consists of medium- to very coarse-grained sandstone; angular and poorly sorted. Clasts estimated to average 30 percent of rock, with a maximum of 90 percent in some beds; clasts poorly sorted and angular to subangular; clasts average two inches in diameter, with a maximum diameter of three feet. Clasts consist of 60 percent leucocratic plutonic rock and 40 percent biotite-rich gneiss and schist.

Ttss: Sandstone, light to medium brown, medium- to coarse-grained and poorly sorted. Beds average three feet thick, graded from very coarse-grained at bottom to medium-grained at top. Partings and beds of fine sandstone and shale similar to Ttsl occur. Loadcasts occur at the base of some sandstone beds.

Notes:

(1) The subsurface thickness shown in column 3 is based on a driller's log and an assumed dip of 45° in the Calwin Oil Company No. 1 well.

(2) The base of the section exposed in column 4 is obscured by the Puente Formation which unconformably overlies the Topanga Formation.


PLEISTOCENE
ALLUVIUM
MIDDLE MIOCENE
TOPANGA FORMATION
1
Qal
Ttsl
Fault
2
Qalo
Ttcg
Ttsl
Ttcg
bs
bs
Ttcg
Surface
Subsurface
Ttsl
Ttcg
Ttcg
Ttsl
3
Qalo
?
Ttsl
Fault
bs
Ttsl
Fault
4
Fault
Ttsl
Ttss
tuff
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Ttsl
bs = break in section
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500
0
Scale (ft)
INDEX MAP
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EXPLANATION
Post-Topanga rocks
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Topanga Formation
Pre-Topanga rocks
3
Section

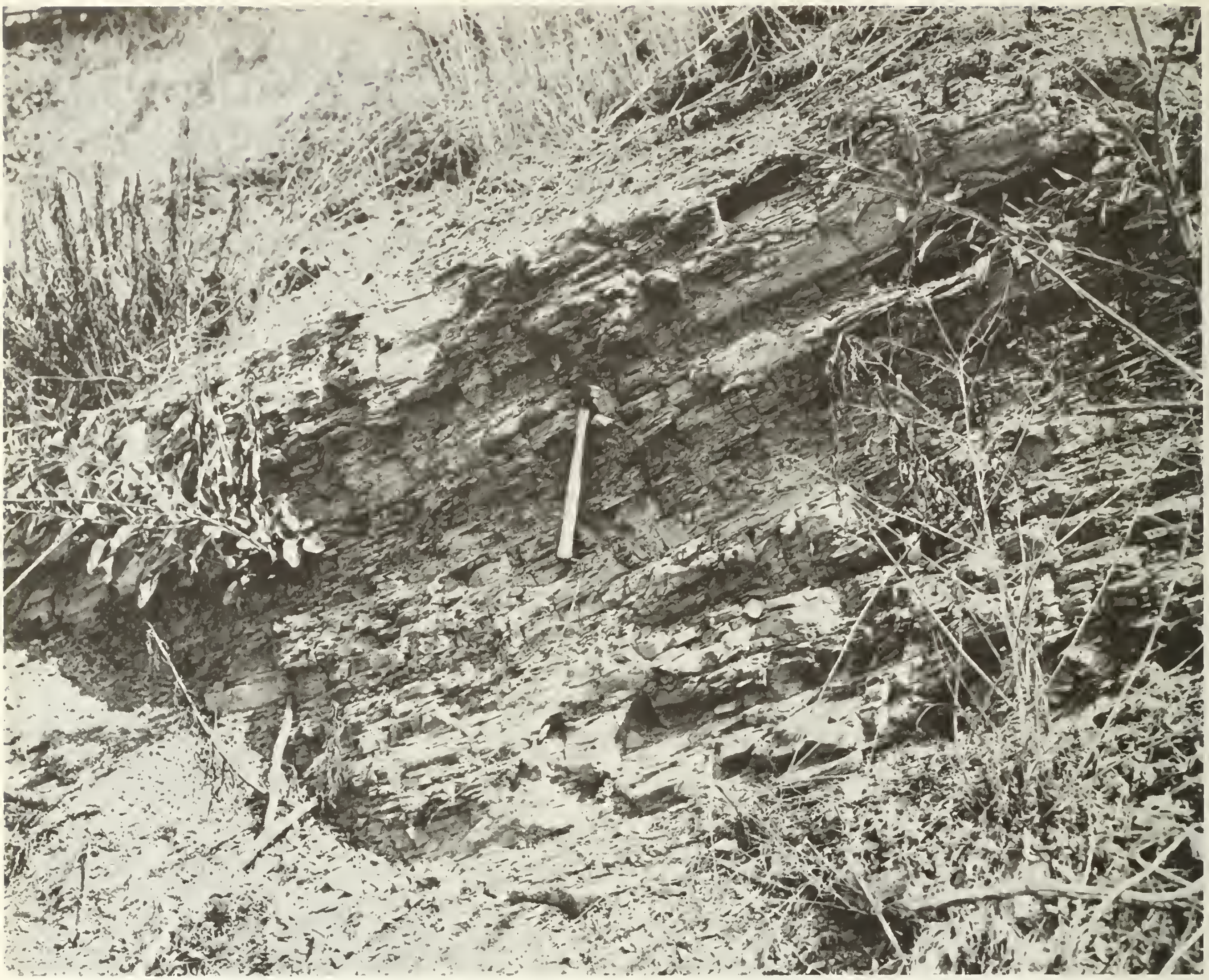


Figure 12. Interbedded Siltstone and Fine-Grained Sandstone, Topanga Formation. The exposure is on Adams Hill in Glendale.

tion of locality 28-24, which is designated as probable early Mohnian, all of the localities in rocks assigned to the Topanga Formation in this area were determined as "early Mohnian or older," "Luisian or Relizian," and "possible Luisian or older." Locality 28-24 occurs near the base of the sequence of Topanga rocks exposed near the east edge of the area. The rocks in the lower part of this sequence are not as sandy as the rocks up section to the north.

Rocks assigned to the Topanga Formation in the Mount Washington area, southwest of the Highland Park fault and at the southeast edge of the Forest Lawn Hills, contain more shale than the rocks to the north. In individual outcrops, some of these rocks appear similar to the platy and siliceous shales in the Puente Formation. These rocks are differentiated from the Puente on the basis of their characteristic blocky weathering, brown color, and the dark brown coating on weathered surfaces.

The Topanga Formation south of the York Boulevard fault also shows features which are characteristic of sediments deposited by turbidity currents. Identifiable Foraminifera were found only at locality 18-9. *Bolvina advena* var. *striatella* from this locality occurs in Natland's (1957, p. 556) biofacies IIIa (Central American province; 125–900 feet; 20° to 11°C). The fish scales identified from the Topanga Formation exposed south of the York Boulevard fault also indicate that this unit was deposited in the open ocean. On Adams Hill these definite marine strata very abruptly interfinger with massive nonfossiliferous conglomerate and breccia. The conglomerate is similar to the massive conglomerate north of the York Boulevard fault except that in places it is so poorly sorted and contains such a high proportion of dark minerals that it has the appearance of weathered basement rock. Along the contact, deformed slabs and blocks of thin-bedded sandstone and shale occur within the conglomerate, suggesting that the coarse material was rapidly dumped into the basin of deposition. The distribution and lithology of the conglomerate indicates that it had a source of rugged basement terrain located northeast of Adams Hill.

Subsurface Distribution

Rocks correlated with the Topanga Formation have been encountered in wells drilled for oil in the northern part of the Los Angeles basin. Electric log characteristics of these rocks are shown in figure 13. W. T. Rothwell (personal communication, 1960) has reported

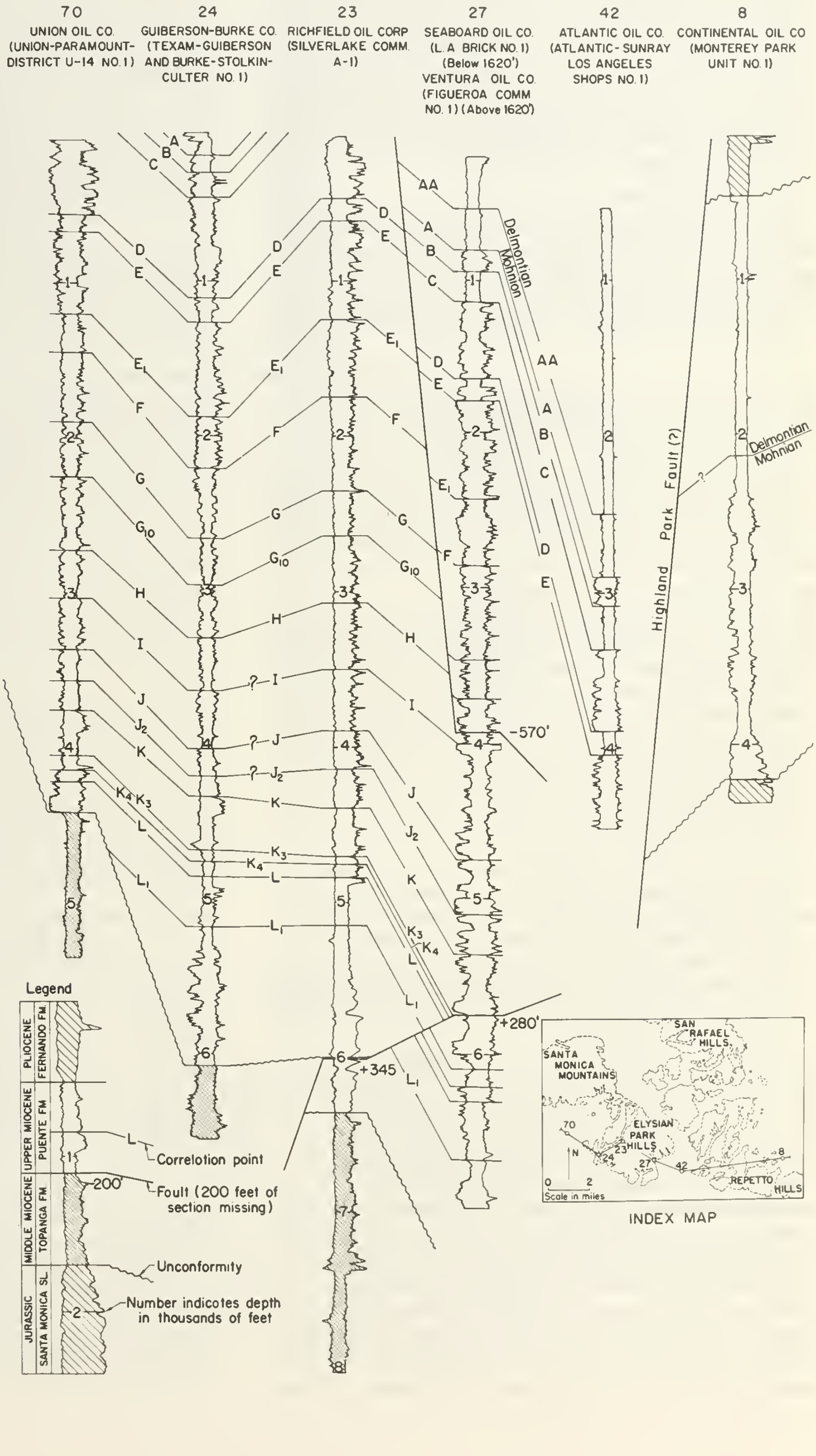

70
UNION OIL CO. (UNION-PARAMOUNT-DISTRICT U-14 NO. 1)
24
GUIBERSON-BURKE CO. (TEXAM-GUIBERSON AND BURKE-STOLKIN-CULTER NO. 1)
23
RICHFIELD OIL CORP (SILVERLAKE COMM. A-1)
27
SEABOARD OIL CO. (L. A. BRICK NO. 1) (Below 1620') VENTURA OIL CO. (FIGUEROA COMM NO. 1) (Above 1620')
42
ATLANTIC OIL CO. (ATLANTIC-SUNRAY LOS ANGELES SHOPS NO. 1)
8
CONTINENTAL OIL CO (MONTEREY PARK UNIT NO. 1)
AA
A
B
C
D
E
E_1
F
G
G_{10}
H
I
J
J_2
K
K_3
K_4
L
L_1
Delmontian
Mohnian
Highland Park Fault (?)
-570'
+280'
+345
1
2
3
4
5
6
7
8
Legend
PLIOCENE FERNANDO FM.
UPPER MIOCENE PUENTE FM.
MIDDLE MIOCENE TOPANGA FM.
JURASSIC SANTA MONICA SL.
Correlation point
200'
Fault (200 feet of section missing)
Unconformity
Number indicates depth in thousands of feet
SAN RAFAEL HILLS
SANTA MONICA MOUNTAINS
ELYSIAN PARK HILLS
REPETTO HILLS
N
0 2
Scale in miles
INDEX MAP

Figure 13.
Electric Log Correlation Section.

Luisian or Relizian fish scales and probable Relizian Foraminifera from the Topanga strata in the Richfield Oil Corporation, Silverlake Community A-1 well. Where paleontologic data were lacking, the following characteristics were used to differentiate the Topanga Formation in subsurface: (1) presence of abundant conglomerate, because except for the basal conglomerate, the Puente Formation contains very little conglomerate in this area, and (2) abrupt increase in dip, as reported in core descriptions or in dipmeter log, which may indicate the unconformity at the base of the overlying Puente Formation.

PUENTE FORMATION

The Puente Formation consists of interbedded and interfingered sandstone, siltstone, shale and rarely conglomerate and conglomeratic sandstone. The lithology of the Puente Formation and the variations in thickness and lithology in the surface and subsurface are described and illustrated in figure 14. The electric log characteristics and the correlations between wells and the columnar sections (fig. 14) are shown in figure 13.

The microfauna in the Elysian Park area was studied by Natland and Rothwell (1954). Dudley (1954) studied the Foraminifera of the Puente Formation exposed in the Mount Washington-El Sereno area. Samples were collected by the author and studied by W. T. Rothwell, Jr. and R. L. Brooks of Richfield Oil Corporation (fig. 9). These studies have shown that in outcrop the Puente Formation contains Foraminifera representative of Kleinpell's (1938) Mohnian and Delmontian Stages.

W. T. Rothwell, Jr. (personal communication, 1960) has reported Foraminifera and fish scales of probable Luisian age in the Puente Formation below a depth of 4800 feet in the Richfield Oil Corporation, Silverlake Community A-1 well. Dipmeter informa-

Figure 14. Columnar Sections of Puente Formation (right).

Tpsl: Siltstone and very fine-grained sandstone; light brown to light gray; poorly cemented and blocky weathering. Bedding planes smooth and regular, beds average ⅛ to ¼ inch thick. Individual laminae commonly faintly graded from coarser at the bottom to finer at the top. Commonly very light gray and diatomaceous. Contains beds of medium- to coarse-grained graded sandstone up to five feet thick. Layers of contorted shale and shale slabs and pebbles of hard orange limestone occur within regularly bedded siltstone sequences. Contains beds of hard gray limestone up to three inches thick.

Tpsh: Shale and siltstone; light gray to dull white and less commonly medium brown. Well-bedded and fissile, beds average 1/16 to ⅛ inch thick. Commonly siliceous, very hard and blocky weathering in layers averaging two inches thick. Regularly interbedded with fine- to coarse-grained sandstone, the thicker beds are the coarser grained, individual sandstone beds commonly are graded from coarser grained at the bottom to finer grained at the top. Bedding planes are smooth and even and outcrops appear banded. Fish scales and mica flakes occur on many of the bedding planes. Contains massive blocky layers of hard orange limestone up to three feet thick.

Tpds: Diatomaceous shale to diatomite, white to very light gray, soft and punky; usually blocky weathering; thinly laminated or banded and regularly bedded, fish scales occur on bedding planes. Contains layers of light gray siltstone up to ½ inch thick and rare interbeds of very soft, friable, medium brown, fine- to coarse-grained sandstone up to ½ inch thick. Sandstone beds are commonly graded from coarser grained at the bottom to finer grained at the top. Contains massive, blocky layers of hard orange limestone.

Tpss: (Sections 1 and 2) Sandstone, medium to light brown weathered, light brown to light gray when fresh, usually hard and well cemented with very hard, calcareous, discoidal concretions; the sandstone in the upper part of the sequence is usually soft and less well-cemented; very fine to very coarse grained, and rarely contains granule-sized grains; varies from thinly laminated fine-grained sandstone to beds of very coarse-grained sandstone over 10 feet thick; the thicker beds usually contain the coarser grains; all gradations exist between outcrops which consist almost entirely of sandstone with siltstone and shale partings to those which consist of interbedded sandstone and shale. The sandstone is poorly sorted and the grains are angular to subangular. Some beds contain up to 20 per cent carbonized wood, which is usually concentrated in the upper portion of the bed. Individual beds are usually graded from coarser grained at the bottom to finer grained at the top, others are very poorly sorted and not graded. Cross-bedding occurs in the thin-bedded fine-grained sandstone. Load casts occur at the base of the thicker, coarser grained sandstone beds; where the undersides of the sandstone beds are exposed, the load casts commonly show a very pronounced lineation (load deformation lineation); the spacing between individual load folds averages two inches and is as much as six inches on some of the thicker beds. Shale and siltstone fragments and slabs and contorted beds of shale occur within individual sandstone beds and are most common in sequences containing abundant interbedded shale and siltstone. The lower contacts of individual beds are abrupt and the upper contacts are usually so; however, some of the standstone beds grade upward into thin-bedded siltstone or shale.

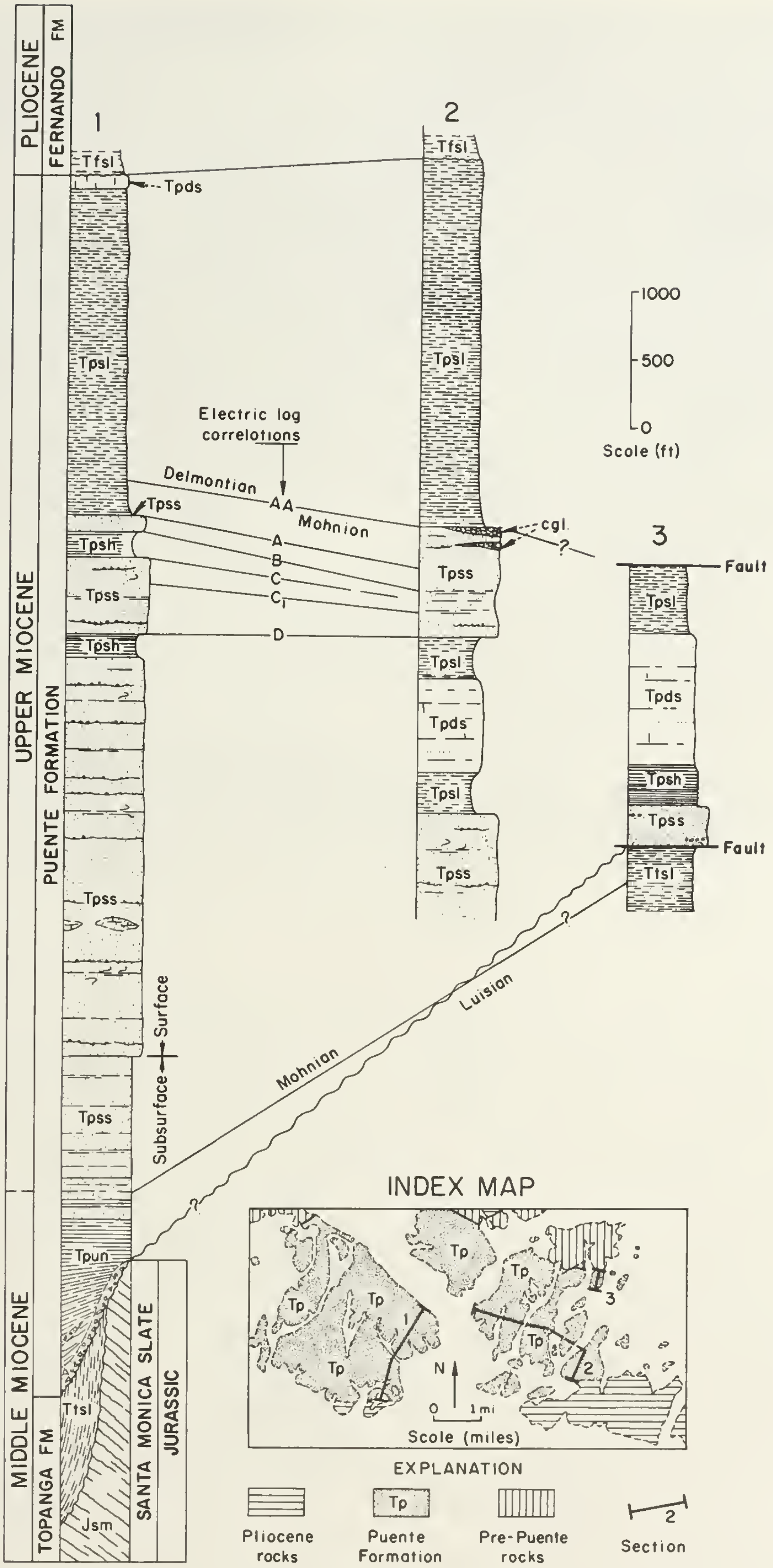
cgl: Conglomerate, occurs as beds and stringers in sandstone. Light gray to medium reddish brown, individual conglomerate layers up to 15 feet thick and consist of up to 80 per cent clasts set in a matrix of coarse-grained sandstone, clasts poorly sorted and average two inches in diameter, the largest clast observed is two feet in diameter. The clasts are deeply weathered, and subrounded, and are predominantly leucocratic plutonic igneous rocks and biotite schist and gneiss. Light gray aphanitic and olive green and pink porphyritic volcanic rocks constitute less than five per cent of the clasts.

Tpun: Sandstone grades downward into and interfingers with shale which in turn grades into coarse-grained sandstone and conglomerate at the base of the Puente Formation. The contacts between sandstone, shale, and the basal conglomerate could not be determined because of insufficient core data.

Shale: dark gray to dark brown, very hard, dense, massive and micaceous, with phosphatic nodules and lenses.

Conglomerate: Consists of up to 95 per cent angular clasts of steel gray slate and rare subrounded quartz fragments set in a matrix of dark brown mudstone and angular sand grains; the clasts are up to two inches in diameter.

Tpss: Section (3) Conglomeratic sandstone, light brown fresh, weathers mottled orange brown to light yellowish green and light brown; soft and poorly cemented to hard and well cemented; more conglomeratic portions are usually better cemented; fine to coarse grained with up to five percent pebbles averaging ½ inch in diameter, largest clast observed is three inches in diameter; pebbles concentrated in bands and stringers. Clasts consist of 60 per cent hard, well rounded fragments of leucocratic igneous rock and 40 per cent angular, hard fragments of siliceous shale and sandstone.


PLIOCENE
FERNANDO FM
UPPER MIOCENE
PUENTE FORMATION
MIDDLE MIOCENE
TOPANGA FM
SANTA MONICA SLATE
JURASSIC
1
2
3
Tfsl
Tpds
Tpsl
Tpss
Tpsh
Tpun
Ttsl
Jsm
Tpds
cgl.
?
Electric log correlations
Delmontian
Mohnian
AA
A
B
C
C₁
D
Surface
Subsurface
Mohnian
Luisian
Fault
Fault
1000
500
0
Scale (ft)
INDEX MAP
Tp
N
0 1mi
Scale (miles)
EXPLANATION
Pliocene rocks
Tp
Puente Formation
Pre-Puente rocks
2
Section

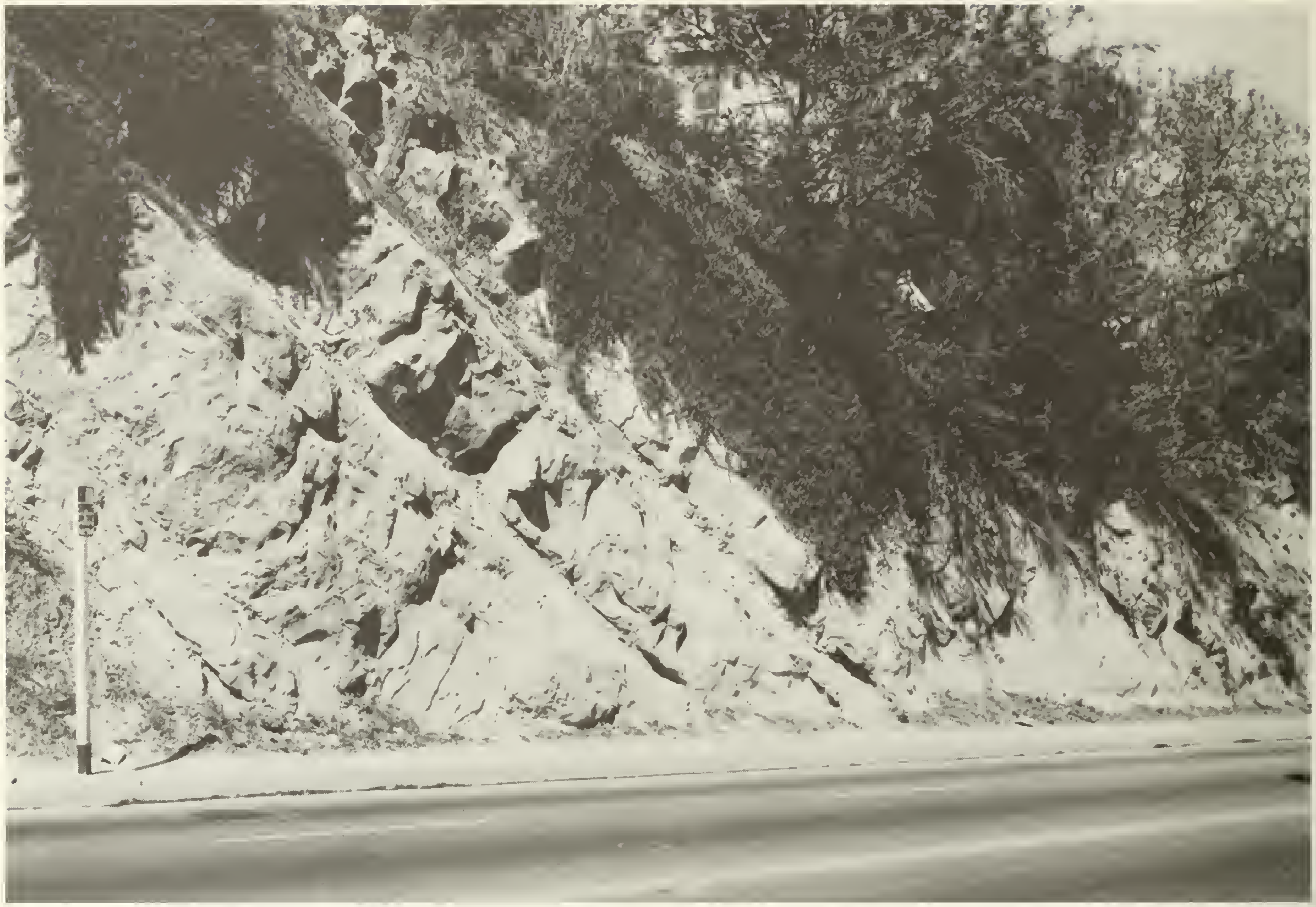


Figure 15. Sandstone and Interbedded Siltstone, Puente Formation. The strata are exposed on the north flank of the Elysian Park anticline, along Glendale Boulevard.

tion, electric log correlations, and core descriptions indicate that some of these strata containing a Luisian fauna are in conformable sequence with the overlying Mohnian rocks. In this area, a basal conglomerate with slate clasts rests unconformably on older Luisian and Relizian strata assigned to the Topanga Formation. Electric log correlations clearly show that to the north these probable Luisian beds buttress against the older rocks and at the Union-Paramount No. 1 well (number 70 on fig. 13); Luisian rocks are very thin above the unconformity. The unconformity was chosen as the base of the Puente Formation (equivalent to Modelo Formation) because, although it may transgress the Mohnian-Luisian stage boundary, it is believed to be equivalent to the unconformity defined as the base of the Modelo Formation in the Santa Monica Mountains (Hoots, 1931, p. 102). Also, as outlined above, the Modelo Formation in its type area includes beds of Luisian age. In the subsurface along the axis of the Elysian Park anticline, the basal conglomerate of the Puente Formation rests on the Santa Monica Slate (?).

The Puente Formation exposed north of the Highland Park fault consists of conglomeratic sandstone overlain by platy and diatomaceous shale. The fragments of siliceous shale and sandstone in the conglomeratic sandstone and the variable thickness of this unit suggest that the conglomeratic sandstone represents a basal conglomerate which unconformably overlies the Topanga Formation. Contortion of beds near the base of the unit at the east edge of the area is believed to be the result of minor faulting along the unconformity.

On the hill north of Emery Park School (T. 1S., R. 12W., sections 8 and 17), Dudley (1954, p. 49) reported a microfossil locality that ". . . could easily be lower Delmontian." According to J. H. Van Amringe of Union Oil Company (personal communication, 1960) microfossils of possible Delmontian age have been reported from the same hill. Therefore, if the base of this sequence rests unconformably on the Topanga Formation, the Puente Formation north of the Highland Park fault may contain a complete section of Mohnian rocks which is approximately 1800 feet thick. Core and paleontologic data suggest that the basal conglomerate of the Puente Formation rests unconformably on the Santa Monica Slate (?) in the Continental Oil Company-Monterey Park Unit No. 1 well (No. 8 in table 2); these data also indicate that the rocks of Mohnian age are 1300 feet thick in this well, as compared to 2100 feet in the Texaco Inc.-Heller No. 1 well (No. 10 in table 2) located to the southwest. The Heller well bottomed in Mohnian rocks.

On the basis of ecologic data on living Foraminifera, which are also found as fossils in the Mohnian portion of the Modelo Formation on the north slope of the Santa Monica Mountains, Sullwold (1958, p. 28) concluded that the depth of water during the deposition of all but the basal conglomerate of these strata was at least 2500 feet and may have been several thousand feet deeper. On similar evidence, Natland (1957, p. 560–561) concluded that during the Mohnian the sea in the Los Angeles basin was more than 2000 feet deep, and gradually deepened to over 4000 feet in the Delmontian, especially in the Los Angeles City area.

Sphaeroidina bulloides was identified from one locality by Dudley (1954) and was also listed by Pierce (1956) from Benedict Canyon on the north slope of the Santa Monica Mountains. According to Sullwold (1958, p. 28), "*Sphaeroidina bulloides* has not been reported in print on the California sea floor above 5400 feet." Rothwell (personal communication *in* Sullwold, 1958, p. 28) has found this Foraminifer in association with other fossils which suggest that it may have lived in water as shallow as 2000 to 3000 feet. Most of the Foraminifera identified by Dudley (1954) and in the present investigation are listed by Pierce (1956) from the Benedict Canyon area, which suggests that these rocks accumulated in similar environments.

Scales of *Xyne grex* were identified from one Puente Formation locality (3-16) in the present study and are common in the upper Mohnian rocks studied in Benedict Canyon. According to David (1943, p. 76) herrings and herring-like fishes similar to *Xyne grex* come toward shore in large schools to spawn in shallow bays but exist in deep water throughout the remainder of the time. The *Cynoscion* species of fish identified from these rocks also suggests an oceanic-bathyal environment (fig. 9).

The Puente Formation shows almost all of the features that Kuenen and Carozzi (1953, p. 364) consider to be typical of sediments deposited by turbidity cur-

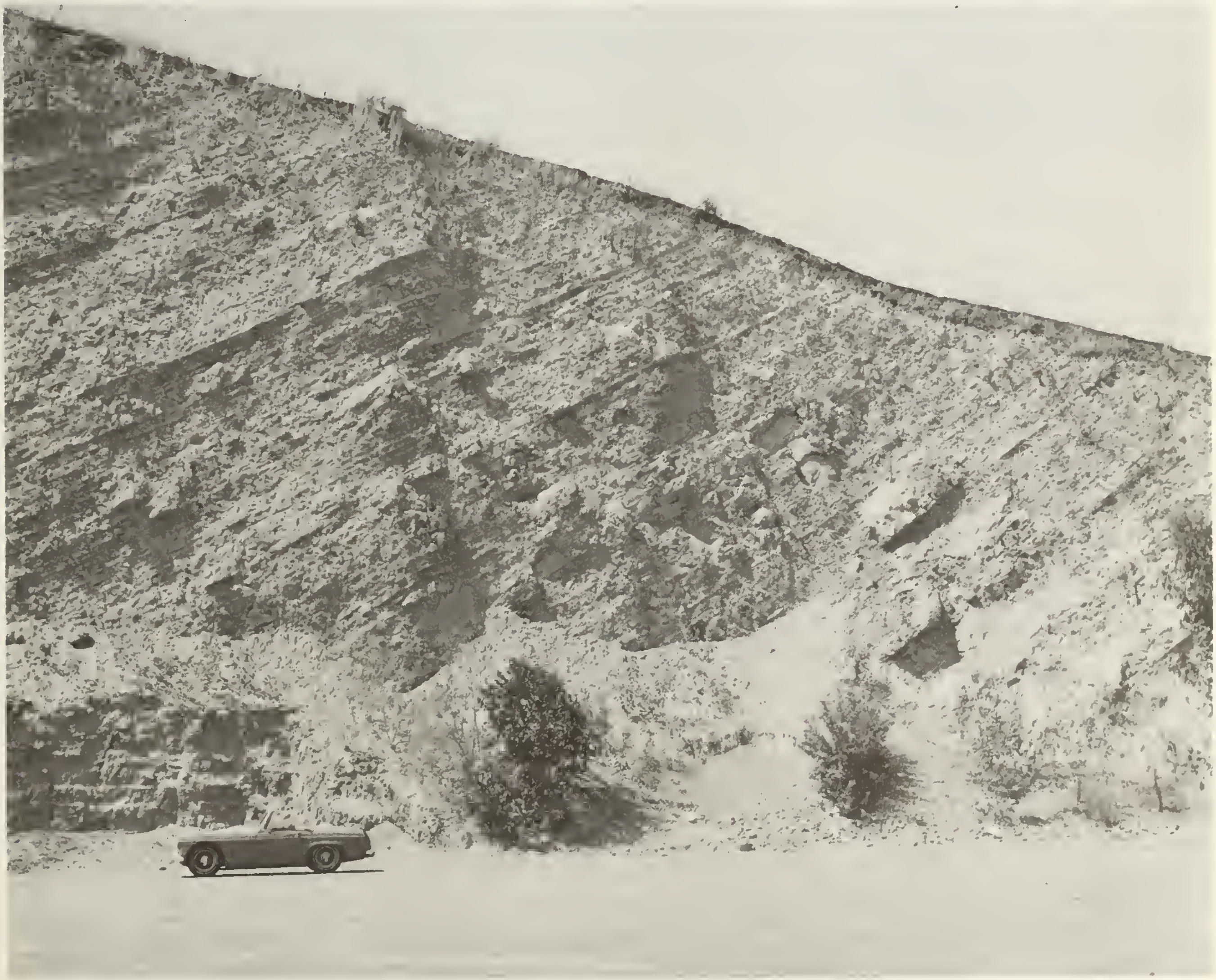


Figure 16. Siltstone, Puente Formation. The upper portion of the formation is exposed in Chavez Ravine.

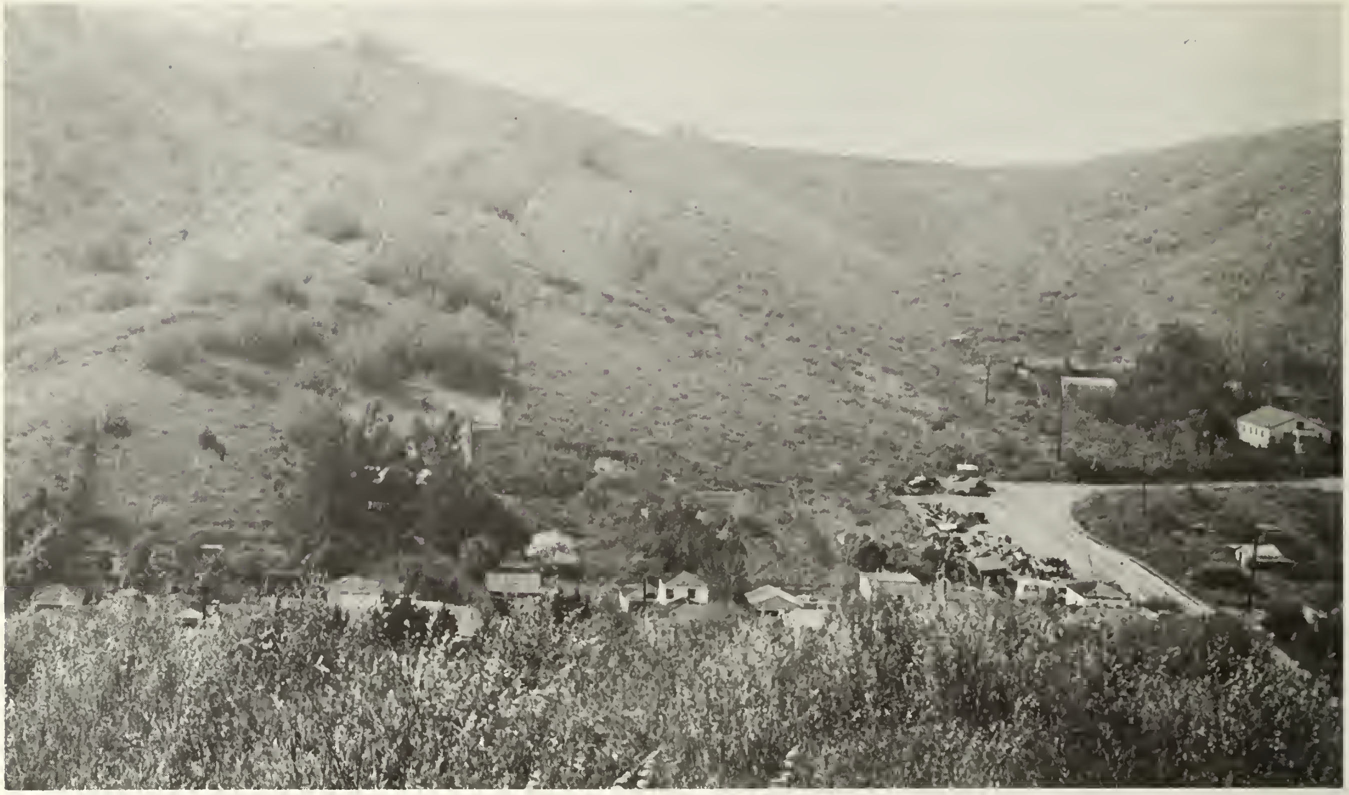


Figure 17. Unconformity Between Puente and Topanga Formations. The slopes are underlain by south-dipping conglomeratic sandstone and shale of the Puente Formation, on the left, which rest unconformably on the Topanga Formation. The photo was taken between Monterey Road and Lomitas Drive in Highland Park.

rents. On the basis of a detailed laboratory and field study, Sullwold (1958, 1960) concluded that the Mohnian portion of the Modelo Formation exposed on the north slope of the Santa Monica Mountains was deposited by turbidity currents as the Tarzana submarine fan. The rocks studied by Sullwold are similar in texture, structure, and lithology to the Puente Formation rocks described in this report.

The dip of cross-bedding and the bearing of load deformation lineations in the Puente Formation were measured and indicate that the Mohnian portion of the Puente Formation below electric log correlation point C was deposited by currents from the northwest (Lamar, 1961). These measurements and the lithologic and faunal similarities indicate that the lower part of the Puente Formation in the Elysian Park-Repetto Hills area represents a portion of the southeast lobe of the Tarzana fan. Between columns 1 and 2 in figure 14 the rocks below electric log correlation point C grade from largely sandstone in the west to largely shale in the east, which fits the northwest source derived from the current direction measurements. The rocks above electric log correlation point C change in the opposite sense and include layers of conglomerate. Conglomerate was not observed in the Mohnian rocks below electric log point C in outcrop in the Elysian Park Hills area, and Sullwold (1958, p. 46) indicates that conglomerate is rare in the Tarzana fan on the north slope of the Santa Monica Mountains. Two measurements in the Mohnian rocks above electric log point C indicate a current direction of S22°W. Although more measurements are required, the available data suggest that, in the Elysian Park Hills area, deposition of the Tarzana fan ceased approximately at electric log point C or before the close of the Mohnian. The Mohnian sediments younger than the Tarzana fan were apparently derived from the northeast rather than the northwest.

The rocks of Delmontian age consist of thin-bedded siltstone to very fine sandstone, with minor amounts of coarser-grained sandstone and pebble conglomerate. In many exposures the bedding of the siltstone is contorted where there is no other evidence of faulting. The field relations indicate that the bedding has been deformed as the result of slumping and sliding contemporaneous with deposition. These contorted siltstones commonly occur intimately associated with coarse-grained, pebbly sandstone layers, which suggests that the deposition of these coarser sediments may have initiated slumping in the previously deposited siltstone beds. The author did not observe any similar slump structures in the shale and siltstone in the sequence that is inferred to be part of the Tarzana fan. An absence of slump structures in the portions of submarine fans far from shore has been noted in the turbidity current deposits in the San Pedro and Santa Monica basins offshore in southern California by Gorsline and Emery (1959). They also noted that slump structures occur on aprons adjacent to the coastal sides of the basin. The observations of Gorsline and Emery (1959) support the conclusion that all but the uppermost part of the Mohnian rocks in the Elysian Park Hills area accumulated several miles from the edge of a basin as a portion of the Tarzana fan and suggest that during the Delmontian and probably the latest Mohnian, the area was located closer to the coast.

SIGNIFICANCE OF THE MOHNIAN-LUISIAN BOUNDARY

Difficulties have arisen in attempts to apply the existing formational and time-stratigraphic nomenclature to the Miocene rocks exposed in the Elysian Park-Repetto Hills area. Part of the problem must be due to the complicated geology which is partly obscured by residential and commercial development. It was found that the most reasonable interpretation of the stratigraphy required modification of the concept that the Mohnian-Luisian boundary is coincident with the Puente (Modelo)-Topanga contact.

In the Elysian Park area a Luisian fauna was reported in the subsurface from rocks which are conformable with overlying strata containing a Mohnian fauna. This sequence of beds containing a Luisian fauna has a conglomerate at the base resting unconformably on rocks assigned to the Topanga Formation in the subsurface.

To the north an irregular band of rocks is exposed across the center of the area. These consist of rhythmically bedded siltstone, sandstone, and shale which interfinger with conglomerate on Adams Hill and perhaps at the east end of the Santa Monica Mountains. The coarser grained portions of the rhythmically bedded rocks yield a late Luisian fauna. The finer grained portions yield faunas of probable earliest Mohnian to Mohnian-Luisian transitional age. If we assign these rocks to the Puente (Modelo) Formation, then the interfingering conglomerates on Adams Hill and perhaps the conglomerate north of the York Boulevard fault must in part correlate with the Puente Formation. If this is true, a similar relationship could also be expected in the Santa Monica Mountains west of Cahuenga Pass. In this area Hoots (1931) originally

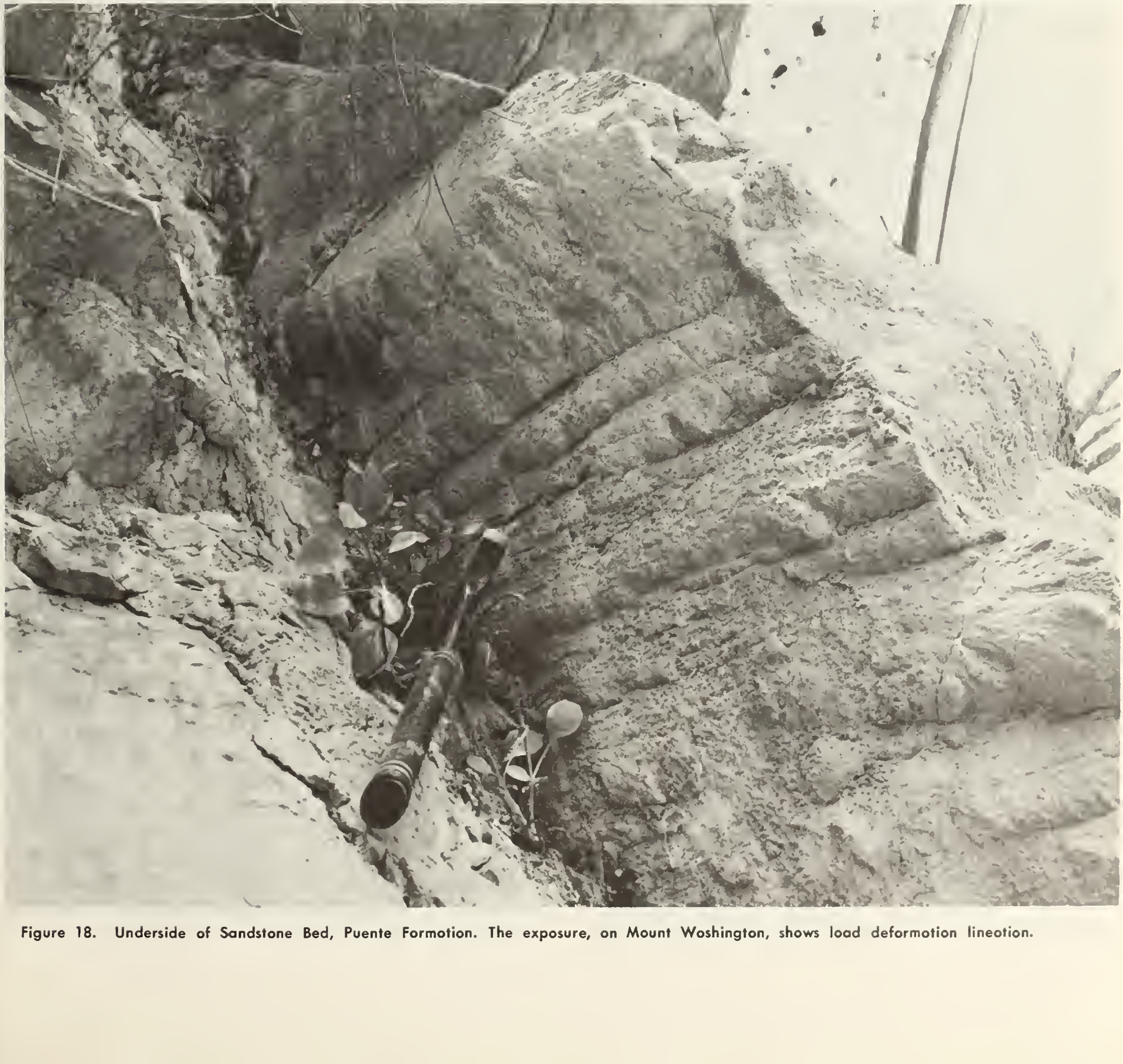


Figure 18. Underside of Sandstone Bed, Puente Formotion. The exposure, on Mount Woshington, shows lood deformotion lineotion.

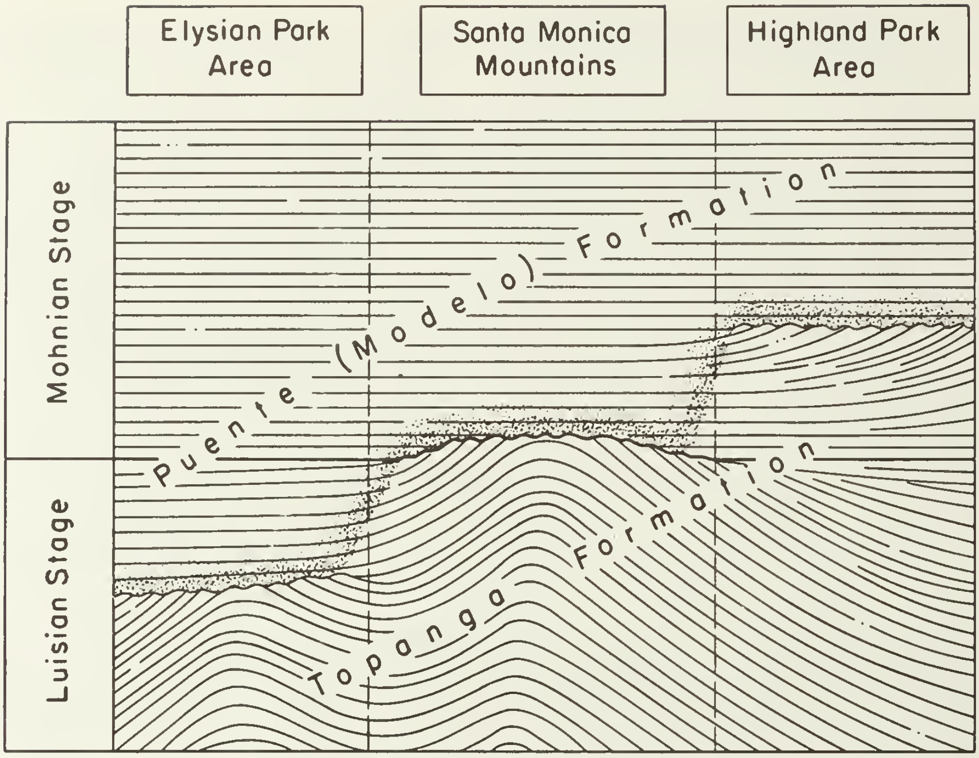


Figure 19. Diagrammatic Section Between Topanga and Puente Formations. The diagram illustrates the relationship between the Topanga and Puente (Modelo) Formations, assuming that the Mohnian-Luisian boundary is a valid "time line."

mapped a sequence of siliceous shale as Modelo Formation. These beds have since yielded a Luisian fauna (Sullwold, 1958; Hardey, 1958). The careful mapping of Harding (1952) and Hardey (1958) reveals that the shale containing a Luisian fauna interfingers with conglomerate similar to that on Adams Hill and is overlain unconformably by rocks of the Modelo formation, which contain a Mohnian fauna. Although the relations are by no means clear, it is believed that the Puente Formation unconformably overlies rocks of the central belt of Topanga rocks southeast of Highland Park.

Thus the paleontologic data indicate contemporaneous deposition above and below the unconformity at the base of the Puente (Modelo) Formation. Transgressive unconformities are not uncommon where the age of the basal rocks varies with position and where all of the beds beneath the unconformity are older than all of the beds above. However, there is no simple relationship for the case where some of the rocks above and below an unconformity are the same age. Of course, distinct unconformities could have formed at different times at different locations, if the Mohnian-Luisian boundary represents a valid "time line." Smith (1960) has suggested this explanation for the same relationship between rocks containing Mohnian and Luisian Foraminifera along the eastern margin of the Los Angeles basin. According to her, "changes in thicknesses of rocks assigned to the Luisian and Mohnian stages are due to unconformities and local depositional variations." If this is the correct explanation in the Elysian Park-Repetto Hills area, figure 19 shows the required relationships *between* Sections 1 and 3 (fig. 14) and the Santa Monica Mountain section. It can be seen that according to this explanation there should be areas in the Los Angeles basin where the Puente-Topanga unconformity fades into a conformable sequence and then reappears at a different horizon. No such relationship appears on any of the published detailed maps and sections of the Los Angeles basin. It is suggested that the Mohnian-Luisian boundary represents in part a change in depositional environment and that Foraminifera and fish representative of the Mohnian and Luisian lived contemporaneously in different areas. The fact that the finer grained portions of the central belt of Topanga rocks yielded faunas determined as probable earliest Mohnian and the coarser grained rocks yielded late Luisian faunas supports this hypothesis. W. T. Rothwell, Jr. (personal communication, 1967) has suggested that the difficulty in correlation across the major faults could be explained if each fault block has behaved independently; thus the age of the unconformity chosen as the base of the Puente (Modelo) Formation could be of different ages in each fault block.

Pliocene Series

FERNANDO FORMATION

Age and Correlation

Massive siltstone, sandstone, and conglomerate overlying the Puente Formation in the southern portion of the area are mapped as the Fernando Formation. Rocks of the Fernando Formation also crop out on Raymond Hill and in a fault block in the Highland Park area. The lithology and variations in thickness of the Fernando Formation are indicated in figure 20.

The term Fernando Formation was originally applied by Eldridge and Arnold (1907, p. 22) to a succession of conglomerate, sandstone, and sandy clay that contains upper Miocene through Pleistocene fossils. These rocks lie between the siliceous shales of the Modelo Formation and non-fossiliferous deposits of probable Pleistocene age in the Santa Clara Valley area. In the Los Angeles City area, Eldridge and Arnold (1907, p. 150–151, and legend pl. XVIII) mapped the beds between the siliceous shales of the Puente Formation (equivalent to the Modelo Formation of the Santa Clara Valley area) and the Quaternary deposits as Fernando Formation. In the Los Angeles City area Eldridge and Arnold indicate that the lower boundary of the Fernando should coincide approximately with the contact between rocks of Miocene and Pliocene age.

In a later report on the Santa Clara Valley area, Kew (1924, p. 69–70) also restricted the term Fernando to beds of post-Miocene age and raised Fernando to group status. Kew divided the Fernando Group into two formations, the younger predominantly non-marine Saugus Formation and the older predominantly marine Pico Formation. Later the name Fernando Group undifferentiated was applied to rocks in the Puente Hills that English (1926, p. 39–44) considered to be of Pliocene age. After Kew's study of the Santa Clara Valley area, geologists assigned the predominantly marine Pliocene in the Los Angeles basin to the Pico Formation.

Subsequent micropaleontologic work revealed two major foraminiferal assemblages in the marine Pliocene sequence of the Los Angeles basin. As outlined by Wissler (1943, p. 212–213), the terminology of the Pliocene rock and faunal units in the Los Angeles basin became so involved that the Pacific Section of the Society of Economic Paleontologists and Mineralogists appointed a committee on nomenclature to establish a uniform classification. In 1930 this committee proposed the name Repetto Formation for the early Pliocene division and restricted the term Pico to the late Pliocene. Woodring (1938, p. 3–4) and Natland (1952, p. 18) have pointed out that these so-called formational units are in reality biostratigraphic units and should be so named. On the basis of Foraminifera, Natland (1952) defined three stages in the Pliocene rocks of southern California. The type section of Natland's lowest Pliocene Repettian Stage is located along Atlantic Boulevard in the Repetto Hills and is in part (Natland, 1952, pl. II) equivalent to the type section of Reed's (1932, p. 31, footnote) Repetto Formation. The present author found that the upper contact of the type Repetto Formation could not be mapped on the basis of lithology and also favors the rejection of the Pico and Repetto formational names in the Los Angeles basin. In this study the term Fernando Formation has been applied to the sequence of rocks lying between the Puente Formation and the younger alluvial and terrace deposits.

In the Elysian Park-Repetto Hills area the contact between the Puente Formation and the overlying Fernando Formation is marked by a lithologic change from thin, well-bedded siltstone and very fine sandstone to massive, very poorly bedded siltstone or mudstone. As shown on the geologic map and cross sections, the contact is an angular unconformity in some of the structurally complex areas and is conformable in other areas. Where the contact is conformable, the lithologic change is gradational and difficult to locate accurately. Where published data (Natland and Rothwell, 1954) are available, the boundaries of the Repettian and Wheelerian (late Pliocene) Stages of the Pliocene defined by Natland are shown on the geologic map (pl. 1).

Published information is available on the paleontology of the rocks mapped as Fernando Formation (Soper and Grant, 1932; Martin, 1952; Natland and Rothwell, 1954). Therefore, the present author has only considered the paleontology of these rocks where his interpretation of the geology is different from that shown by previous workers and where important data are either unpublished or not referred to by recent investigators.

As shown on the geologic map (pl. 1) the Fernando Formation wraps around the Puente Formation rocks at the eastern end of the Elysian Park anticline and fills a re-entrant synclinal area to the north. This distribution of Fernando is based on lithology and is supported by a report of "lower Repetto" Foraminifera from the upper part of the Continental Oil Company (Monterey Park Unit No. 1-1) well.

Megafossils were collected from one locality in the rocks mapped as Fernando Formation exposed in the fault block in the Highland Park area. Hertlein and Grant (1944, p. 13–14) reported a Pliocene locality from the same general area; they list a brachiopod species from the locality. Dudley (1954, p. 53) has reported megafossils from similar rocks exposed on Raymond Hill. The megafossils collected by the author and Dudley are listed below:

Raymond Hill, U.C.L.A. locality no. 4385. Collected by Paul H. Dudley, Jr., and identified by him and J. G. Vedder (Dudley, 1954, p. 53).

Gastropoda
- *Cancellaria hemphilli* Dall?
- *Crepidula* sp. ?
- *Neverita* sp.
- *Turritella cooperi* Carpenter

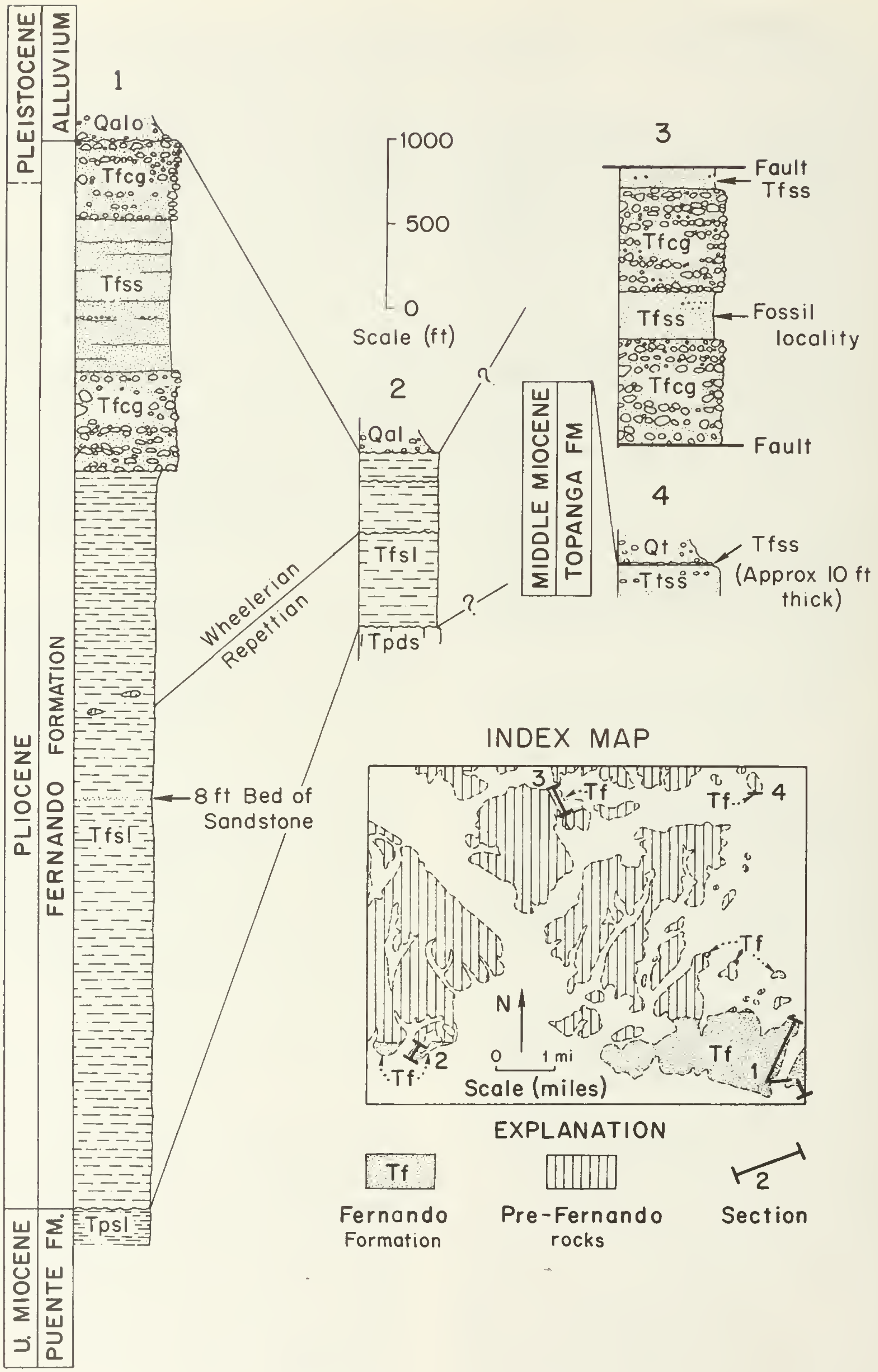

PLEISTOCENE
ALLUVIUM
PLIOCENE
FERNANDO FORMATION
U. MIOCENE
PUENTE FM.
1
Qalo
Tfcg
Tfss
Tfcg
Tfsl
Tpsl
8 ft Bed of Sandstone
Wheelerian
Repettian
1000
500
0
Scale (ft)
2
Qal
Tfsl
Tpds
?
?
3
Fault
Tfss
Tfcg
Tfss
Fossil locality
Tfcg
Fault
MIDDLE MIOCENE
TOPANGA FM
4
Qt
Tfss
Tts
Tfss (Approx 10 ft thick)
INDEX MAP
3
Tf
Tf
4
Tf
N
Tf
1
2
Tf
0 1 mi
Scale (miles)
EXPLANATION
Tf
Fernando Formation
Pre-Fernando rocks
2
Section

Figure 20. Columnar Sections of Fernando Formation (left).

Tfcg (section 1): Conglomerate, light brown to rust brown and very poorly cemented. Clasts are subrounded to subangular and are predominantly leucocratic plutonic and gneissic rocks. The largest clasts are about two inches in diameter. The matrix consists of fine- to very coarse-grained sandstone which is very soft and poorly sorted.

Tfcg (section 3): Conglomerate and coarse conglomeratic sandstone; soft poorly sorted and glistening white to brick red; the different colors occur in alternating layers as much as 10 feet thick. Some layers contain as much as 60 per cent clasts. Clasts average two inches in diameter; the largest clast observed is six inches in diameter. Clasts consist of hard, rounded leucocratic plutonic rocks and as much as 40 per cent angular fragments of hard sandstone, limestone, and shale similar to the Miocene sedimentary rocks in the area.

Tfss (sections 3 and 4): Sandstone, light tan to dull white, very fine grained, massive, very soft and micaceous. Contains scattered rounded pebbles which average ¼ inch in diameter. Poorly preserved mollusk shells occur in rust brown stained sandstone.

Tfss (section 1): Sandstone, gray to brown, rarely red brown, fine to medium grained, rarely coarse grained to pebbly; friable, well bedded, coarser grains occur in beds which are the thickest; beds up to four feet thick. Finer-grained beds are thinly laminated. Beds are commonly graded from coarser grained at the bottom to finer grained at the top. Load costs occur at the base of individual beds.

Tfsl: Siltstone, weathers light brown, light to medium gray in fresh exposures. Massive, in weathered outcrops the attitude of bedding is difficult to determine. Soft and very micaceous. Contains rare very hard calcareous beds and concretions which are light gray. Layers of conglomerate with a matrix of soft, rust brown sandstone occur in section 2. The clasts are predominantly gray, very hard limestone (90 per cent limestone with diatomaceous shale and basalt according to Conrey, 1959, p. 59). In the upper part of the siltstone section in the Repetto Hills (west of section 1) a few layers of hard, well-cemented conglomerate, which consists of well raunded pebbles and shell fragments, are exposed. These conglomerate beds are lenticular and have a maximum thickness of four feet. The clasts are predominantly leucocratic igneous and gneissic rocks. In section 1 beds of pebbly sandstone occur in the siltstone. The sandstone is coarse grained, rust brown in color and very soft and poorly sorted. The pebbles are angular and as much as ¼ inch in diameter.

Notes:

(1) The thickness of the Repettian Stage Shown in section 1 is from Natland (1952, p. 19).

(2) The eight-foot bed of sandstone shown on section 1 corresponds to the top of the Repetto Formation as defined by Reed (1932, p. 31, footnote; see Natland, 1952, pl. II).

(3) The thickness and location of unconformities shown on section 2 are from Soper and Grant (1932, p. 1050).

(4) The locations of the Repettian-Wheelerian contact on sections 1 and 2 are from Natland and Rothwell (1954).

Pelecypoda
- *Panope generosa* Gould
- *Pecten (Aequipecten)* sp.
- *Thracia trapezoides* Conrad
- *Chione* cf. *securis* Shumard var. *fernandoensis* (English)

Highland Park, U.C.L.A. locality no. 4024. Collected by Donald Lamar. Identified by Takeo Susuki.

Gastropoda
- "*Argobuccinum*" *(Fusitriton) oregonense* Redfield
- *Cancellaria* cf. *obesa* var. *planospira* Grant and Gale
- *Cancellaria tritonides* Gabb
- *Terebra* sp.
- *Trophon (Boreotrophon)* cf. *stuarti* Smith

Pelecypoda
- *Chione* cf. *securis* Shumard var. *ferandoensis* (English)
- *Nuculana* sp.

In the opinion of Takeo Susuki and J. G. Vedder (personal communications, 1967), these assemblages are of probable Pliocene age but are possibly as old as late Miocene. Samples collected from these localities by the author and W. H. Holman were found to be barren of Foraminifera. Although the paleontologic data are insufficient to assign an unqualified Pliocene age to these rocks, they have been mapped as Fernando on the basis of their lithologic similarity to Fernando rocks exposed in the Repetto Hills and because in the Highland Park area they contain clasts of hard sandstone, limestone, and shale similar to the Miocene sedimentary rocks.

Conditions of Deposition

Repetto Hills-Los Angeles City Area. According to Woodring (1938, pl. 4), megafossils of the shallow water, land and fresh-water facies, shallow- to deep-water facies, and deep-water facies occur in rocks of Lower Pliocene age in the Los Angeles City area and in the Repetto Hills. Woodring (1938, p. 16) suggests that the mollusks of shallow-water facies from the Third Street Tunnel in Los Angeles, which consist of broken and worn specimens, indicate transportation by some unknown agency. According to Martin (1952, p. 113), the Foraminifera that he studied in the Los Angeles City area are representative of Natland's (1933, p. 227–228) zone IV (depth range 900 to 6500 feet). Also, Natland (1952, p. 50) has concluded that the rocks comprising the Repettian Stage were deposited in waters deeper than 4000 feet. Martin (1952, p. 115) has suggested that the shallow-water fossils noted by Woodring in the Los Angeles City area may have been transported into deep water by turbidity current or submarine slides.

Along the south edge of the Repetto Hills the massive siltstone is overlain unconformably by conglomerate which is included in the Fernando Formation. The conglomerate is unfossiliferous; therefore, its age is known only as late Pliocene or younger. Previous

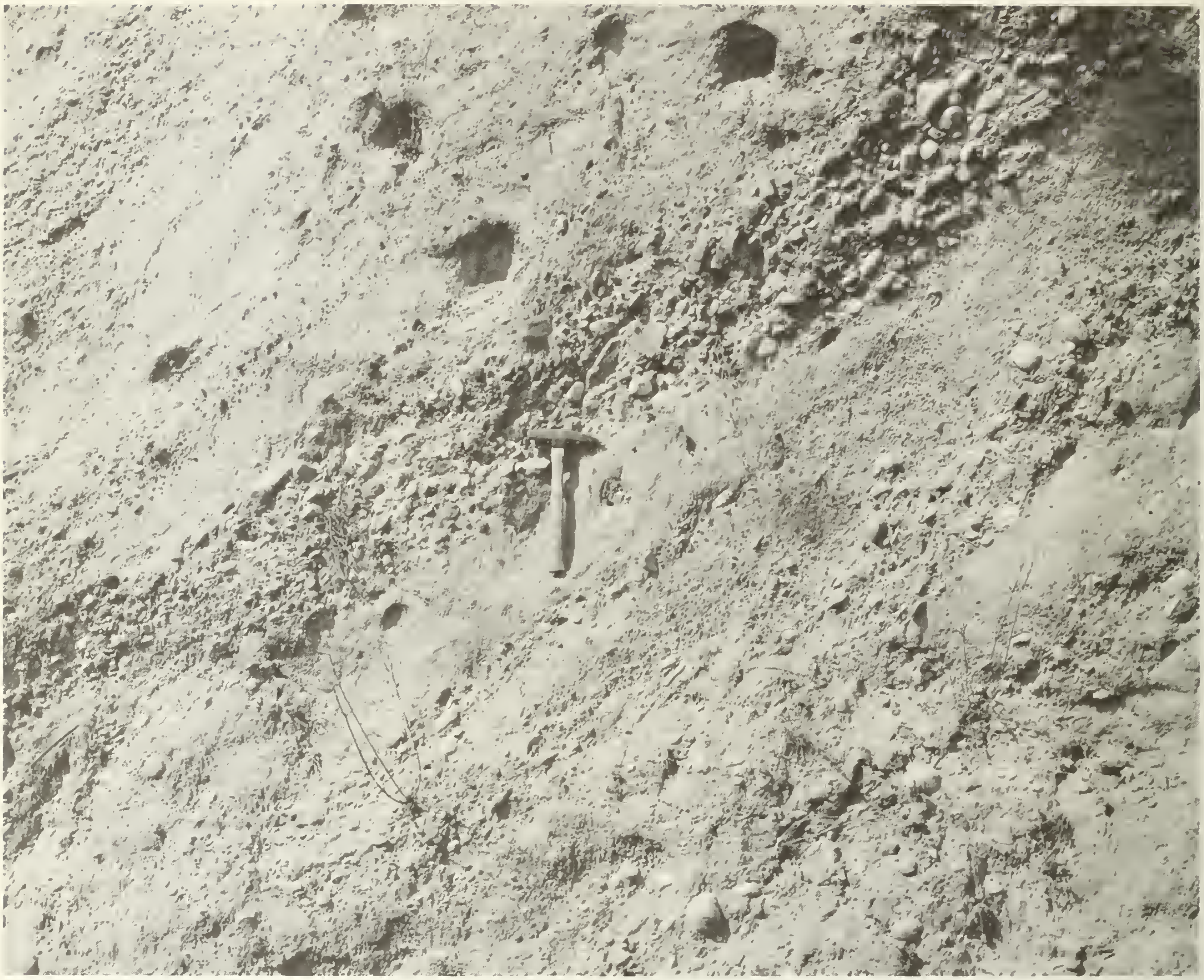


Figure 21. Interbedded Conglomerate and Sandstone, Fernando Formation. The strata appear in the upper portion of the formation, along Garfield Avenue on the south slope of the Repetta Hills.

workers (Edwards, 1934, p. 800; Wissler, 1943, p. 212) have suggested that these conglomerate beds are nonmarine in origin. Although these conglomerates are poorly sorted, they are fairly clean and lack the hard clayey matrix typical of some of the alluvial terrace deposits. These conglomerates may be all or partly marine in origin.

As illustrated in figure 20 and by Conrey (1959, p. 23), the lower Pliocene (Repettian) strata increase in thickness from west to east. According to Conrey, the maximum thickness of lower Pliocene rocks in the Los Angeles basin occurs in the Whittier Narrows area in the vicinity of the Montebello oil field. Conrey's detailed study indicates that the major portion of the lower Pliocene sediments in the Los Angeles basin formed as a submarine fan that had a point source north of the Whittier Narrows area.

Highland Park-Raymond Hill Area. Because most mollusks now live in the photic zone of the sea (Natland, 1957, p. 544), it is suggested that the mollusks collected from the Fernando Formation in the northern part of the area also lived in shallow water. None of the shallow- to deep-water and deep-water mollusks recognized by Woodring (1938, pl. 3) was identified in the collections, and one species ("*Argobuccinum*" (*Fusitrition oregonense* Redfield) is considered by Woodring to indicate shallow water. Although the fossils are poorly preserved, latex casts made from natural molds indicate that the shells are unbroken and unworn. This suggests that the shells were not transported prior to deposition.

The brick-red conglomerate and conglomeratic sandstone in the Fernando Formation exposed in the Highland Park area are similar in color and texture to rocks of the Sespe Formation exposed in other parts of southern California. Reed (1929) and Vander Hoof (1953) have suggested that the Sespe is a non-marine deposit derived from a deeply weathered region of strong relief. By analogy it seems reasonable that part of the conglomerate in the Fernando in the Highland Park area had a non-marine origin.

The available lithologic and faunal data indicate that the Fernando exposed in the Highland Park area was deposited in a shallow-water marine and non-marine environment. The rocks are probably equivalent to a portion of the deeper water facies of the Fernando present in and exposed around the Los Angeles basin. They may also be equivalent to the Duarte Conglomerate of possible Pliocene age described by Shelton (1946) from the northern edge of the San Gabriel Valley.

Pleistocene to Recent Series

TERRACE DEPOSITS

Dissected alluvial terrace deposits occur in the Pasadena area, north of the Raymond fault and in the foothills at the south edge of the area. These deposits are inferred to be Pleistocene to Recent in age. The terrace deposits consist of brown to red-brown rubble conglomerate. The clasts are predominantly leucocratic igneous rocks. Stratification is shown by alternations of beds with up to 90 per cent clasts within sandy layers. The terrace deposits along the south edge of the Repetto Hills are lithologically similar to the steeply dipping conglomerate in the upper part of the Fernando Formation.

ALLUVIUM

Alluvium covers the extensive lowland areas. Dissected older alluvial deposits are differentiated from more recent material occurring on the flood plains. Along portions of the Arroyo Seco and the Los Angeles River, at least two alluvial terrace surfaces are reflected in the topography. The alluvium consists of poorly sorted and consolidated silt, sand, and gravel.

LANDSLIDES

Three landslides were mapped in Griffith Park, in the northwestern part of the area, and another was mapped in Elysian Park along the southwest side of

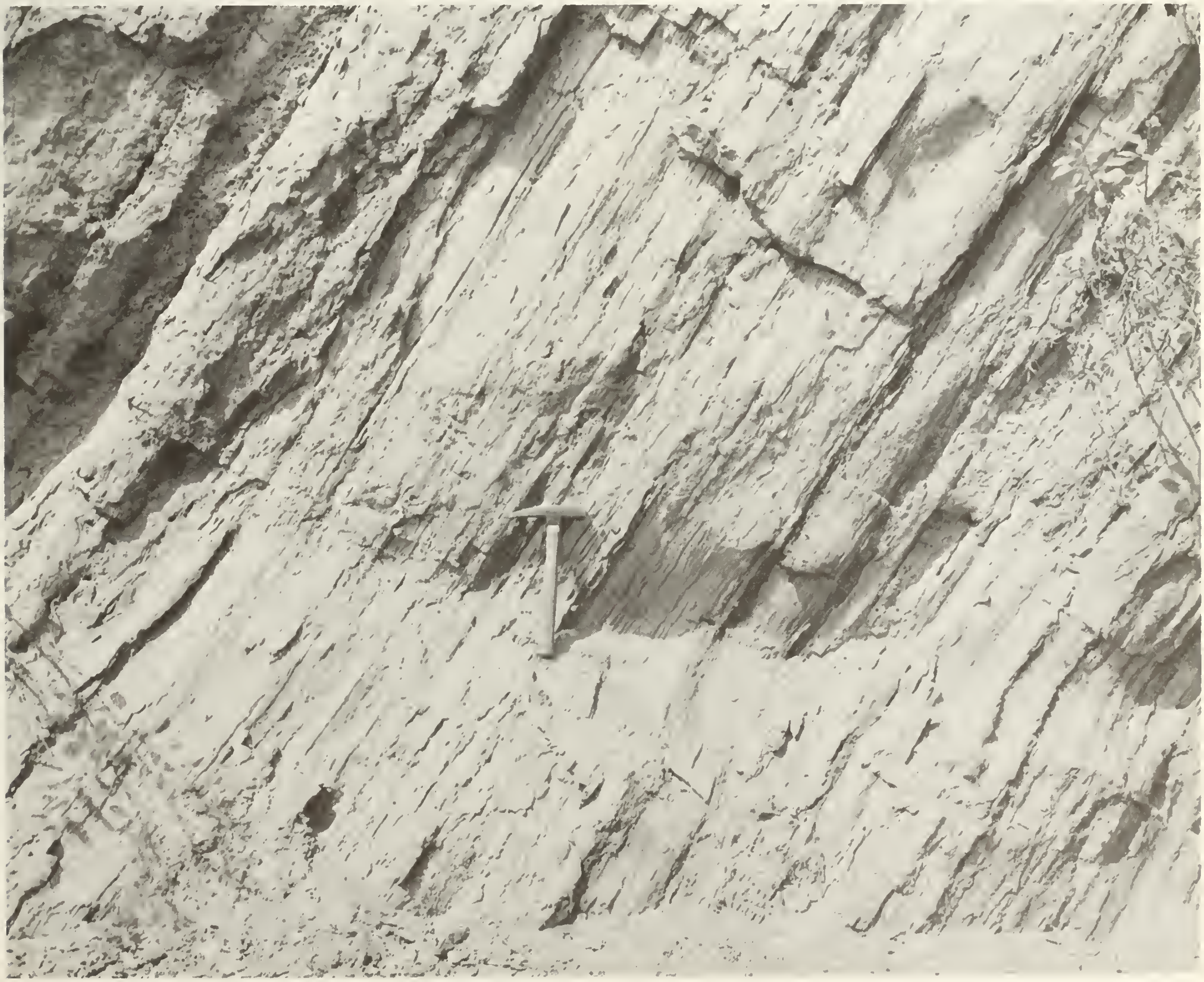


Figure 22. Interbedded Siltstone and Sandstone, Fernando Formation. The siltstone and fine sandstone appear in the upper portion of the formation, along Garfield Avenue on the south slope of the Repetto Hills.

the Los Angeles River. Other landslides may be present, but the intensive development of the land has obscured details of surficial features so that characteristic topographic forms no longer are easily identified by inspection.

The landslides in Griffith Park occurred probably as the result of failure along bedding planes, because the natural slope is steeper than that of the bedding and beds "daylight" on the slope. The landslide in Elysian Park was probably the result of oversteepening due to erosion from the Los Angeles River and as a result of grading along Riverside Drive. At this locality the bedding is favorably oriented with respect to the slope. Planes of weakness dipping out of the slope could have formed as the result of movement along the Elysian Park fault, which apparently passes beneath the landslide debris. This slide was active in 1937 when it blocked Riverside Drive (Jennings and Troxel, 1954, p. 12).

STRUCTURAL GEOLOGY

As shown in figure 2, the Elysian Park Repetto Hills area is at the intersection of the east- to northeast-trending faults of the Santa Monica fault system and the northwest-trending faults that are believed to form a northwest continuation of the Whittier fault system. Details of the fault pattern at the northern margin of the basin are shown in figure 24.

The structure of most of the area is not only extremely complicated but difficult to decipher because of a cover of streets, homes, and vegetation. To aid interpretation of the map (pl. 1) in areas where the structure is complicated, the attitude symbols have an arrow pointing down dip where graded bedding, load casts and other sedimentary structures indicate the tops or up-section direction. A conventional attitude symbol is used at points where the up-section direction is inferred on the basis of faunal succession or structural interpretation.

Abrupt changes in thickness and lithology of the Puente and Topanga Formations occur across the major faults in the Elysian Park-Repetto Hills area. Rapid facies changes also occur within individual fault blocks. The horizontal movement on some of the faults may be larger than the dimensions of the area studied. It is, therefore, necessary to consider the distribution of rocks beyond the Elysian Park-Repetto Hills area to determine whether the changes across faults may be explained by major horizontal movement. Unpublished work of this nature (Lamar, 1961) suggests that the faults of the Whittier and Santa Monica systems have had important components of horizontal movement during certain periods of their

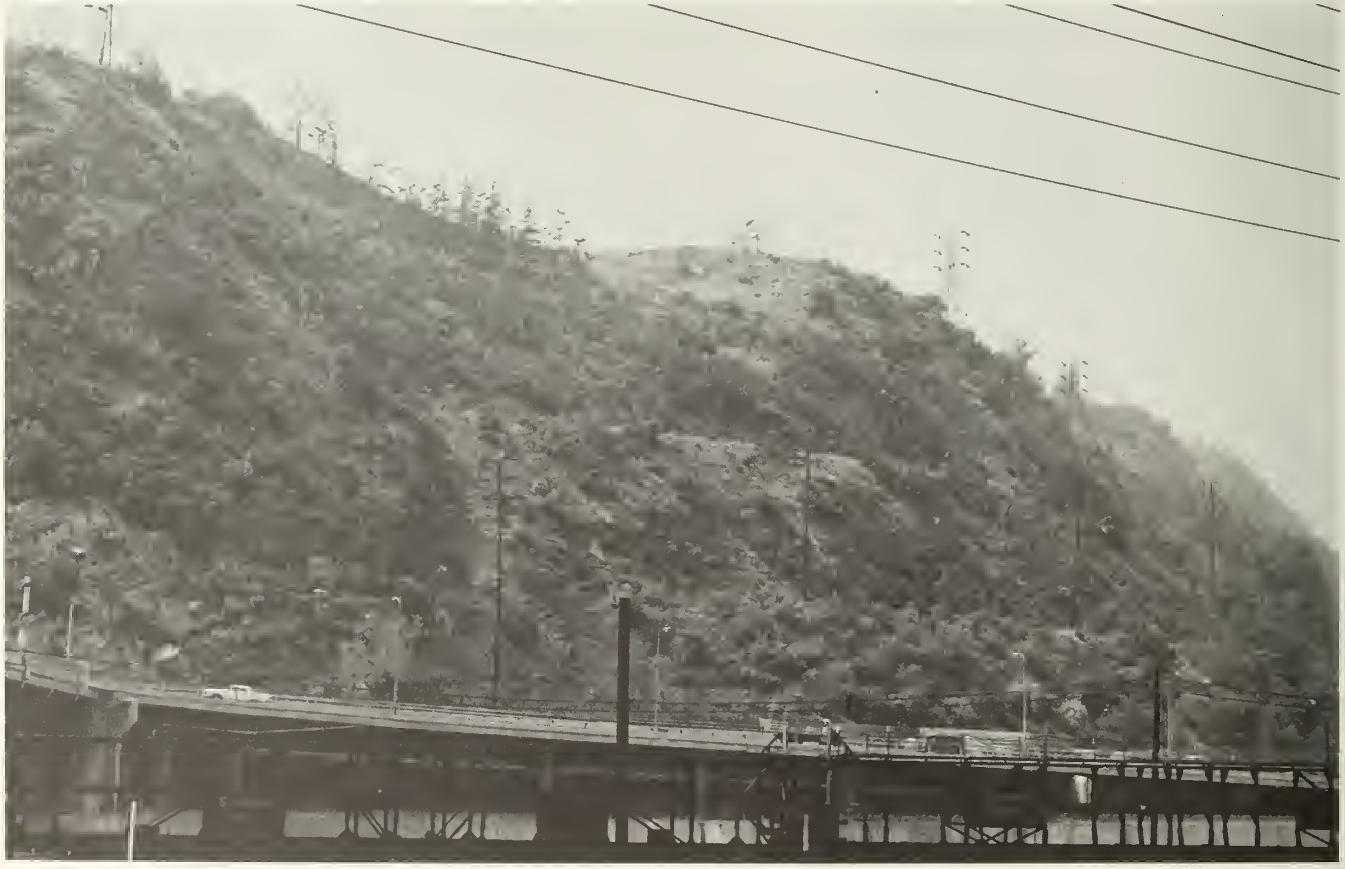


Figure 23. Landslide, Elysian Park. The sliding is along the southwest side of the Los Angeles River. South-dipping sandstone of the Puente Formation is exposed on the left.

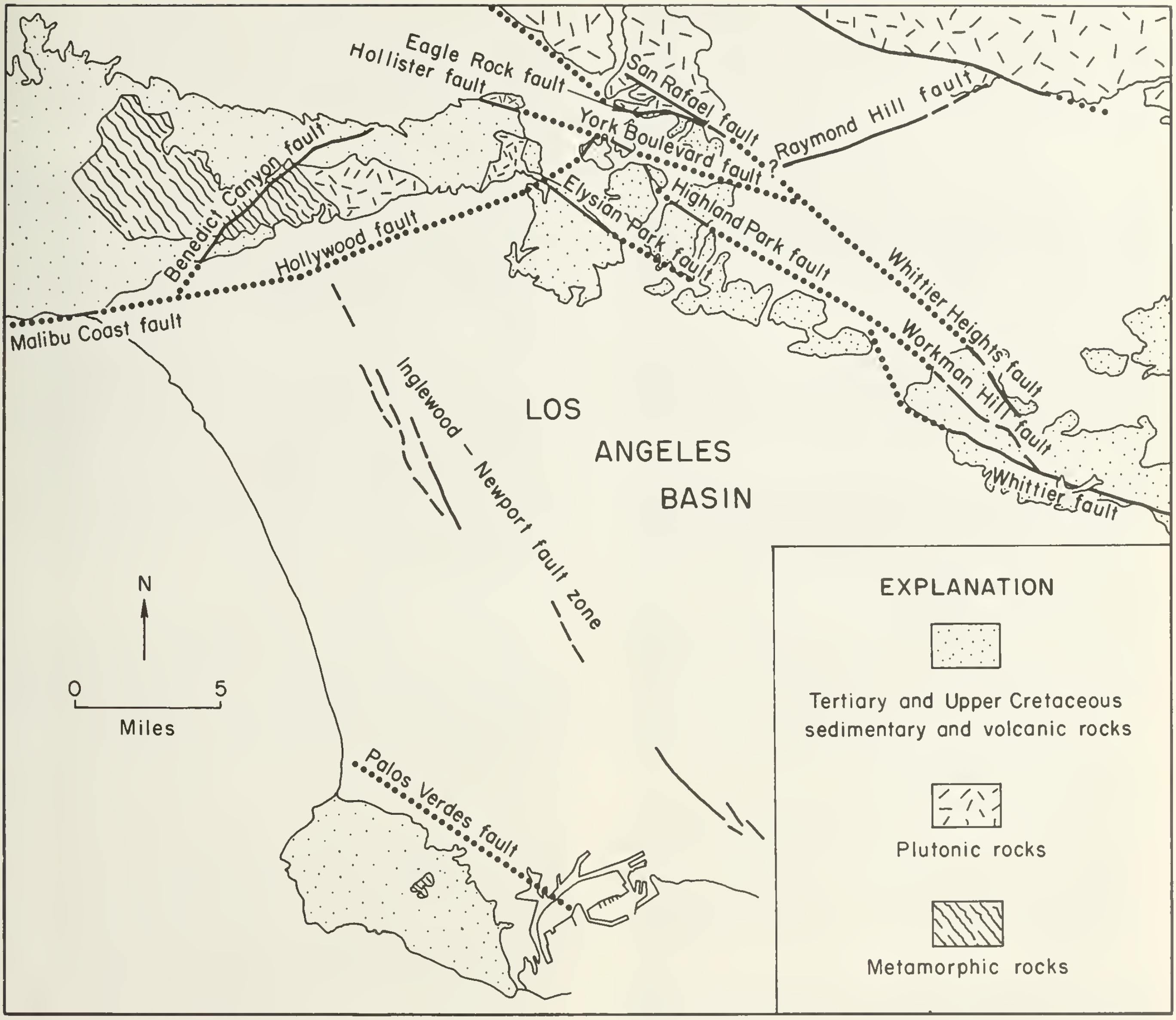


Figure 24. Major Faults in a Portion of the Los Angeles Basin Area. The map is modified from Woodford *et al.* (1954) and Kundert (1955).

history. It is planned to present the results of this study in another paper that will include reference to data not available at the time the thesis work was accomplished. Barbat (1958) and Yerkes *et al.* (1965) have presented summaries of the structure of the Los Angeles basin.

Santa Monica Fault System

Barbat (1958, p. 65) applied the term Santa Monica fault system to the east- to northeast-trending faults along the southern boundary of the Transverse Range province. In the Los Angeles basin area and vicinity (fig. 24) the faults in this system include the Malibu Coast, Hollywood, Benedict Canyon, and Raymond Hill faults.

MALIBU COAST FAULT

The Malibu Coast fault, which parallels the southern slope of the Santa Monica Mountains, was named and described by Soper (1938, p. 171 and 175) in the Malibu area. Soper's geologic map does not show the western continuation of the fault; however, he noted (p. 175) that the fault continues west and extends beneath the ocean west of Point Dume. The trace of the Malibu Coast fault is also shown on maps prepared by Schoellhamer and Yerkes (1961), Schoellhamer *et al.* (1962), Yerkes *et al.* (1964) and Campbell *et al.* (1966). East of Malibu the trace of the fault is hidden by the ocean. Northwest of the city of Santa Monica, the trend of the coast turns to the southeast and several east-northeast-trending faults are exposed. On the basis chiefly of trend and similarity in displacement and attitude to the Malibu Coast fault, R. F. Yerkes (personal communication, 1967) believes that the fault which strikes N78°E and brings marine Pliocene rocks on the north against upper Pleistocene strata on the south (see Hoots, 1931, pl. 16, where lat. 34°02′ crosses shoreline) represents the eastern continuation of the Malibu Coast fault. North of Santa Monica the Malibu Coast fault apparently splits into the Hollywood fault, which continues east-northeastward, and the Benedict Canyon fault, which cuts obliquely northeast across the Santa Monica Mountains.

HOLLYWOOD FAULT

Hoots (1931, p. 129) suggested on the basis of physiographic evidence that a fault is present along the south edge of the Santa Monica Mountains. The position of the trace shown in figure 24 is based on the following:

1. The fault zone between rocks of the Puente Formation and the Feliz Granodiorite in the Elysian Park Hills (pl. 1) is aligned with the probable eastern extension of the Malibu Coast fault northwest of Santa Monica.
2. Data from wells drilled north of Beverly Hills indicate the existence of a north-dipping fault zone with a minimum of 1500 feet of vertical separation at the base of the Modelo Formation (Lamar, 1961, pl. V and Knapp, 1962). The location of the fault in the subsurface is compatible with the trace suggested by the surface evidence outlined above.
3. McCulloh's (1957) gravity map of the northwestern part of the Los Angeles basin shows a steep gravity gradient in the position of the Hollywood fault as shown in figure 24. According to McCulloh, this steep gradient is almost certainly the result of the Hollywood fault.

The vertical separation is a minimum of 6500 feet across the Hollywood fault and the fault that is parallel to it in the area between the Elysian Park Hills and the Santa Monica Mountains. East of the Los Angeles River it is inferred that the Hollywood fault represents the northeast-trending fault between the Wilson Quartz Diorite and Topanga Formation on Forest Lawn Memorial Park. The presence of sedimentary rocks of probable Luisian age in a shallow core hole directly southwest of the Wilson Quartz Diorite on Forest Lawn (fossil locality no. 1) suggests that the Hollywood fault has been offset in a right lateral direction along a northwest-trending fault. The fault that parallels the Hollywood fault on the south probably reappears as the fault contact between the Topanga and Puente Formations south of Eagle Rock Boulevard. To the east, as shown on plate 1, these northeast-trending faults are apparently truncated and offset by northwest-trending faults.

Several additional unnamed northeast-trending faults are present. It is inferred that these faults form a portion of the Santa Monica fault system, which has been fragmented by faults of the northwest-trending Whittier fault system. The most significant of these brings the Fernando Formation (Pliocene) against the Topanga Formation in the Highland Park area. The absence of the Puente Formation requires a minimum of 2000 feet of vertical separation.

RAYMOND HILL FAULT

The trace of the Raymond Hill fault in the Pasadena area is marked by a difference in water levels in wells on opposite sides of the fault, a distinct topographic break, and by north-dipping fault surfaces in the alluvium (Eckis, 1934; Buwalda, 1940). A steepening in the gradient of gravity occurs over the fault (Sanford, 1958, pl. II and IV). According to Sanford (p. 134), the gradient may be explained by about 600 feet of bedrock (pre-alluvium surface) displacement, the north side having moved up. The pronounced topographic break marking the course of the fault does not appear in the alluvium west of the Arroyo Seco. Intense folding in Topanga rocks at the south edge of the San Rafael Hills may be the result of drag along the western continuation of the fault. If the fault continues west it merges with, or is offset by, the York Boulevard fault.

Whittier Fault System

As shown in figure 2, the Whittier fault zone is parallel to the southwest edge of the Puente Hills. In the central and southeastern parts of the Puente Hills, the fault zone consists of several parallel and interbranching faults, which form a zone of complex structure as much as a mile wide. At the northwest end of the Puente Hills the Workman Hill fault and Whittier Heights fault appear to split from the Whittier fault zone (fig. 24). The northwestern continuations of these faults are hidden under the alluvium of the San Gabriel Valley. To the northwest, in the Elysian Park-Repetto Hills area, northwest-trending faults form a zone of complex structure five miles wide between the Elysian Park and San Rafael Hills faults. It is suggested that the major northwest-trending faults which split from the Whittier fault zone at the northwest end of the Puente Hills and the wide zone of northwest-trending faults in the Elysian Park-Repetto Hills area represent a widened northwest continuation of the Whittier fault zone.

ELYSIAN PARK FAULT

The Elysian Park fault is exposed in Elysian Park where the dip symbols are shown. The fault surface is not exposed over the rest of its trace. The relations at the southeast end of the fault indicate that the fault and the associated drag folds are pre-Pliocene in age. Correlation of beds across the fault on structure section B-B′ suggests that the maximum vertical separation is 2100 feet.

HIGHLAND PARK FAULT

The Highland Park fault is exposed as the northwest-trending contact between the Fernando and Topanga Formations northwest of Highland Park. The fault is apparently truncated at its northwest end by the York Boulevard fault. It is inferred that the fault continues southeast of Highland Park and is situated directly southwest of the Continental Oil Company well at the southeast edge of the area. The abrupt change in thickness of the rocks of Mohnian age between this well and the other wells to the south and west is believed analogous to the change in the surface sections across the fault noted in the Highland Park area. At the north end of the fault the entire Puente Formation, or a minimum of 2000 feet of section, is absent. It is inferred that the vertical separation at the base of the Fernando Formation southwest of the Continental well is a minimum of 1000 feet, the north side having gone down.

YORK BOULEVARD FAULT

The York Boulevard fault is exposed in the hills immediately southeast of the John Muir School at the northwest edge of the area. In the central part of the area Pliocene rocks are inferred to be faulted against basement rocks. Because of the incomplete nature of the Pliocene and upper Miocene sections and the possibility that the base of the Fernando Formation (Pliocene) could be an unconformity, the amount of vertical separation is difficult to estimate. The northwest end of the York Boulevard fault is aligned with the Hollister fault (Neuerburg, 1953, pl. I), which also has basement exposed on the north side. In view of the thickness of the sedimentary units that are missing, due at least in part to displacement along the York Boulevard fault and its probable continuation to the northwest, the vertical separation could be more than 10,000 feet. The amount of horizontal separation is unknown.

EAGLE ROCK FAULT

The Eagle Rock fault forms the contact between basement rock and the Topanga Formation at the northern edge of the area. The vertical separation on the fault is a minimum of 6000 feet. The horizontal separation is unknown. The Eagle Rock fault trends northwest between the Arroyo Seco and Eagle Rock. West of Eagle Rock the trace of the fault forms a broad "S" curve and strikes east. At the west edge of the San Rafael Hills the fault again strikes northwest and lines up with the southwest edge of the Verdugo Hills. According to Corbato (1963), gravity data suggest the presence of a major fault along the southwest edge of the Verdugo Hills. This fault is inferred to represent the northwest continuation of the Eagle Rock fault.

SAN RAFAEL FAULT

The San Rafael fault is exposed in the Arroyo Seco as the contact between basement rock and the Topanga Formation. The minimum vertical separation along the fault in the Arroyo Seco is about 1000 feet. Northwest of the mapped area, Scholl, Sycamore, and Verdugo Canyons are offset right laterally an average of 1000 feet along the trace of the inferred northwest continuation of the fault. Within the mapped area stream courses are not affected by the fault. The trace of the Raymond Hill fault, as reflected in a topographic break, changes strike abruptly at the probable intersection with the San Rafael fault. The Pliocene rocks on Raymond Hill appear to be conformable with Topanga rocks that are overturned, probably as a result of drag folding along the San Rafael or Raymond Hill faults.

History of Fault Movement

The map relations indicate that the Elysian Park fault, the northwest-trending faults to the south, and associated drag folds are of pre-Pliocene age. To the northeast the Highland Park fault has had major post-Pliocene movement and is truncated by the York Boulevard fault to the northeast. The San Rafael and Eagle Rock faults are at the northeast edge of the area and are the only northwest-trending faults that have affected stream courses and topography. Although the critical relationships are largely obscured by alluvium, the available surface data suggest that west of the Los Angeles River the Hollywood fault truncates the northwest-trending faults in the Elysian Park Hills area and in the Santa Monica Mountains. Immediately east of the river in the Mount Washington area, the northwest-trending faults continue across and offset the east- to northeast-trending set. These relations also suggest that the northwest-trending faults in the northeast part of the area are the younger. Recent movement along the Raymond Hill fault has formed a scarp in the alluvium that does not continue west of the Arroyo Seco. The relationship between the Raymond Hill and San Rafael faults, both of which have evidence of recent movement, is obscure.

The complicated mosaic of intersecting faults in the area mapped in detail (pl. 1) is what would be expected at the intersection of two major strike-slip fault systems that have been active contemporaneously and have had opposite directions of slip. The Whittier fault system fans out at the northwest edge of the Puente Hills. This observation could be explained by left-lateral movement on the Santa Monica fault system. The Santa Monica fault system widens and splits in an analogous way in the area of intersection.

Folds

The Elysian Park anticline is a major structure which trends N69°W between the Hollywood and Highland Park faults. The absence of middle Miocene Topanga rocks on the crest of the structure indicates a period of folding prior to the deposition of the Puente Formation.

Numerous other unnamed folds appear on the geologic map and structure sections. Most of the fold axes strike between west-northwest and east and intersect the northwest-trending faults at an average of about 30°. The folds are tighter and more closely spaced close to the faults and all but the major structures die out at a distance. These relations suggest that the folding is secondarily related to movement on the faults. Hill and Dibblee (1953, p. 466) have noted locally developed east-trending folds adjacent to the San Andreas fault and feel these are drag folds result-

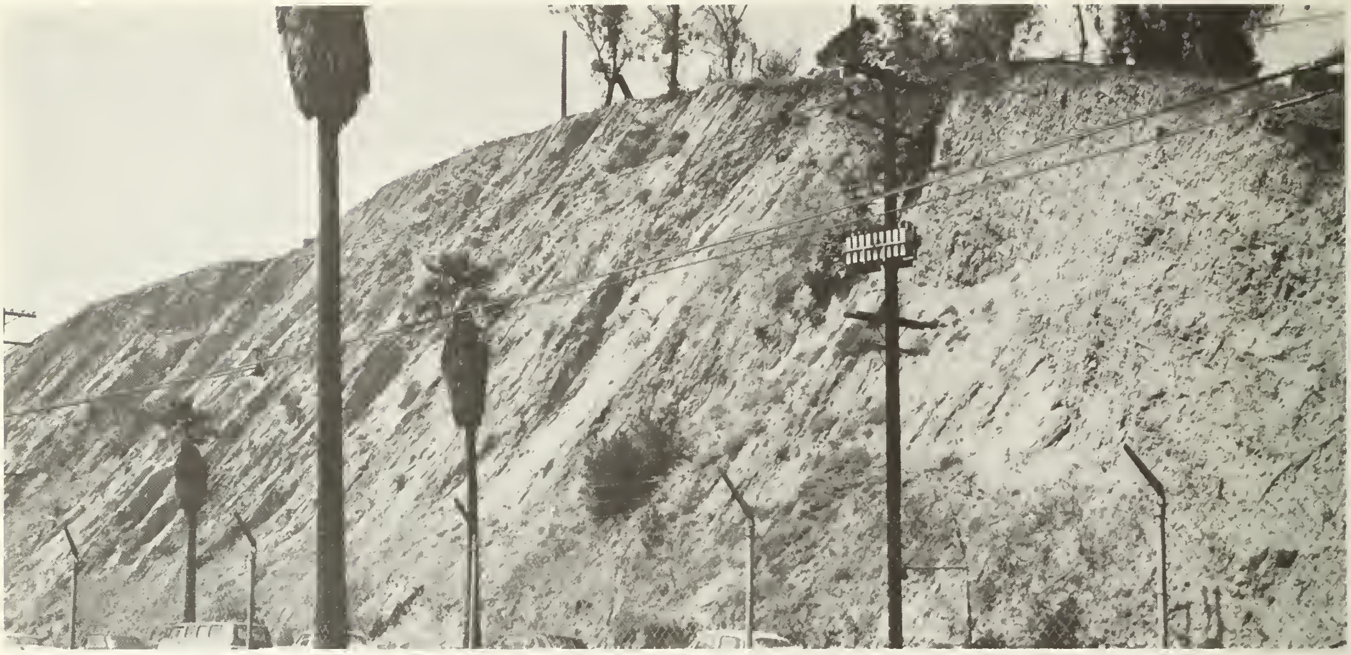


Figure 25. Anticline in Siltstone, Puente Formation. The exposure is along Mission Road in the Lincoln Heights area.

ing from right-lateral movement on the San Andreas fault.

PETROLEUM GEOLOGY

Table 2 lists exploratory wells drilled for oil and selected producing wells through December 31, 1965. The data are largely from the California Division of Oil and Gas (1964a; 1964b, p. 172; 1965).

Los Angeles City Oil Field

The approximate original limits of production of the Los Angeles City oil field are shown on plate 1 (from pl. XIV, Eldridge and Arnold, 1907). This field was discovered in 1892 and produced more than a million barrels of oil per year for a few years (Watts, 1901, p. 53). Information on the geology, history, and oil production of this field appears in Watts (1897, 1901), Eldridge and Arnold (1907), Soper (1943), and Crowder (1961). Previous workers have suggested that the northern limit of production is controlled by a fault or flexure. The dips steepen near the northern edge of the field but the existence of a fault cannot be established on the basis of the exposures. The following facts suggest that a tar seal forms the trap: (1) discovery of field based on oil seeps, (2) shallow production of low-gravity oil (12–20° A.P.I.), and (3) limits of production parallel the strike of bedding. Some scattered exposures of sandstone north of the limits of production in the western part of the field may represent the producing horizon.

Boyle Heights Oil Field

The Boyle Heights oil field was discovered in 1955 by the Richfield Oil Corporation, Boyle Industrial No. 1-1 well. The cumulative production to January 31, 1964 was 178,935 barrels of oil (California Division of Oil and Gas, 1964b, p. 96). This field has been described by Jamison and Malloy (1958). The Boyle Heights oil field is situated on the Boyle Heights anticline. The structure is obscured by alluvium, although the existence of an anticline is suggested by the topography and by some north dips in the terrace deposits and old alluvium. The inferred surface trace of the anticlinal axis lies south of the field, suggesting that the axial plane dips north.

Downtown Los Angeles

In 1964 Standard Oil Company of California discovered "what might be a major oil field in downtown Los Angeles" in their Venice Community no. 1 well (no. 68 in table 2); this well flowed at a rate of 300 barrels a day from the interval between 3440 and 3550 feet in rocks of late Miocene age (California Division of Oil and Gas, 1964b, p. 146). Several additional wells have been drilled (California Division of Oil and Gas, 1965). The direction in which these wells were drilled and the possible limits of production are not known to the author.

BIBLIOGRAPHY

Barnhart, Percy, 1936, Marine fishes of southern California: Univ. of Calif. Press, Berkeley, Calif.

Barbat, W. F., 1958, The Los Angeles basin area, California: in "Habitat of Oil," Am. Assoc. Petrol. Geol., Tulsa, Oklahoma, p. 62–77.

Bergen, F. W., 1955, A restudy of the upper Mohnian-lower Delmontian boundary near Calabasas, California: unpublished Master's thesis on file at Univ. of Calif., Los Angeles, 62 p.

Buwalda, John, 1940, Geology of the Raymond basin: unpublished report prepared for the Pasadena Water Department, 131 p.

California Division of oil and gas, 1964a, Exploratory wells drilled outside of oil and gas fields in California to December 31, 1963, 320 p.

California Division of oil and gas, 1964b, Summary of Operations, Vol. 50, No. 2.

California Division of oil and gas, 1965, Regional wildcat map No. W1-3.

Table 2. Exploratory Wells and Selected Oil-Producing Wells.[1]

Map No.	Operator	Well	Location			Year	Total depth (feet)
			San Bernardino Base & Meridian				
			Sec.[2]	T	R		
1	Calwin Oil Co.	No. 1	(34)	1N	13W	1920	6138
2	J. J. Rekar	Evans 1	18	1S	12W	1922	1100
3	Ferguson Dotz	..	19	1S	12W	Unkn.	1200
4	Norman McDonald	No. 1	19	1S	12W	1921	1138
5	Yellowstone Oil Co.	Castruccio 1	19	1S	12W	1931	2014
6	Jordan Crude Oil Co.	No. 1	19	1S	12W	1916	2460
7	D. Whiting	..	19	1S	12W	Unkn.	500
8	Continental Oil Co.	Monterey Park Unit 1-1	22	1S	12W	1956	4427
9	Standard Oil Co.	Monterey 2	28	1S	12W	1910	3500
10	Texaco Inc.	Heller 1	28	1S	12W	1960	8363
11	Dumm Brothers	Olympic Refining 16	29	1S	12W	1946	4938
12	Puente Oil Co.	Rowland 1	29	1S	12W	1910	2600
13	Richfield Oil Corp.	Boyle Comm. 33-1	31	1S	12W	1946	5902
13	Richfield Oil Corp.	Boyle Comm. 33-1 Redrill	31	1S	12W	1946	5650
14	Boyle Royalties Co.	Boyle Comm. 104-1	31	1S	12W	1949	4500
15	W. H. Taylor	No. 1	32	1S	12W	1929	5825
16	Dollar Oil Co.	No. 1	32	1S	12W	Unkn.	3834
17	Richfield Oil Corp.	Hellman 1	33	1S	12W	1918	2468
18	William Sullivan	No. 1	(6)	1S	13W	1918	2410
19	Seaboard Oil Co.	Park 1	(9)	1S	13W	1944	2300
20	I. H. Preston	Grandview 1	(11)	1S	13W	1916	1195
21	Headley	..	(13)	1S	13W	Unkn.	840
22	Seaboard Oil Co.	Corehole 5	(14)	1S	13W	1945	2732
23	Richfield Oil Corp.	Silverlake Comm. A-1	(17)	1S	13W	1958	8045
24	Guiberson-Burke Co.	Texam et al. 1	(19)	1S	13W	1959	6544
24	Guiberson-Burke Co.	Texam et al. 1 Redrill	(19)	1S	13W	1959	4151
25	E. G. Burke	U-13 Comm. 1	(20)	1S	13W	1959	4865
26	Ventura Oil Co.	Figueroa Comm. 1	(21)	1S	13W	1956	1816
27	Seaboard Oil Co.	L. A. Brick 1	(21)	1S	13W	1945	7505
28	Paul R. McKensie	T. No. 2	(22)	1S	13W	1956	2676
29	Ventura Oil Co.	Freight Depot 1	(22)	1S	13W	1958	1907
30	Standard Oil Co.	Edison Corehole 1	(23)	1S	13W	1963	4693
30	Standard Oil Co.	Edison Corehole 1 Redrill	(23)	1S	13W	1963	3512
31	Dumm Brothers	Olympic Refining 15	(24)	1S	13W	1945	1260
32	Schirm & Rubenstein	Huntington-Segar 1	(24)	1S	13W	1930	3919
33	Calif. Pacific Oil Co.	Lucille 2	(24)	1S	13W	1922	2125
34	O'Donnell & Wilde	No. 1	(24)	1S	13W	1922	2700
35	Republic Petroleum Co.	Jordan 1	(24)	1S	13W	1936	1567
36	Scott & Loftus	No. 1	(25)	1S	13W	Unkn.	875
37	DeSoto Oil Co.	..	(25)	1S	73W	1898	700
38	Amalgamated Oil Co.	Huntington 2	(25)	1S	13W	1919	3745
39	Far East Oil Co.	..	(25)	1S	13W	Unkn.	930
40	Amalgamated Oil Co.	Huntington 1	(25)	1S	13W	1917	3664
41	Scott & Loftus	No. 2	(25)	1S	13W	Unkn.	803
42	Atlantic Oil Co.	Atlantic-Sunray-L.A. Shops 1	(26)	1S	13W	1956	4500
43	Rapid Transit	No. 1	(26)	1S	13W	Unkn.	640
44	H. M. Green	..	(26)	1S	13W	Unkn.	2935
45	Joseph Herron	No. 1	(26)	1S	13W	1922	615
46	Ventura Oil Syn.	No. 1	(26)	1S	13W	1922	856
47	Santa Fe Mutual Oil Syndicate	No. 1	(26)	1S	13W	1927	2995
48	C. Bell	No. 1	(26)	1S	13W	1922	600

Table 2. Exploratory Wells and Selected Oil-Producing Wells.[1]—Continued

			Location				
			San Bernardino Base & Meridian				
Map No.	**Operator**	**Well**	**Sec.[2]**	**T**	**R**	**Year**	**Total depth (feet)**
49	Rees		(26)	1S	13W	Unkn.	825
50	F. F. Hoard	No. 1	(27)	1S	13W	1923	435
51	Standard Oil Co.	Bixel Corehole 1	(29)	1S	13W	1964	4214
52	Standard Oil Co.	Salvation Army Corehole 1	(32)	1S	13W	1963	6225
53	Richfield Oil Corp.	West Adams Corehole 1	(31)	1S	13W	1963	6501
54	Richfield Oil Corp.	West Adams Corehole 2	(32)	1S	13W	1964	6040
55	Standard Oil Co.	Broadway Corehole 1	(32)	1S	13W	1963	6220
56	Standard Oil Co.	Kohler Corehole 1	(33)	1S	13W	1964	3518
56	Standard Oil Co.	Kohler Corehole 1 Redrill	(33)	1S	13W	1964	6284
57	Richfield Oil Corp.	L.A. River Fee 1	(34)	1S	13W	1948	4618
58	Industrial Royalties	Corehole 1	(34)	1S	13W	1954	2130
59	Richfield Oil Corp.	L.A. River Comm. 1-1	(34)	1S	13W	1947	4414
60	Standard Oil Co.	Southern Pacific 57-1	(34)	1S	13W	1960	9524
61	Richfield Oil Corp.	Boyle Comm. 17-1	(35)	1S	13W	1948	5868
62	Richfield Oil Corp.	Evergreen 1	(36)	1S	13W	1957	7110
63	Boyle Royalties Co.	Taylor 1	(36)	1S	13W	1949	4857
64	Standard Oil Co.	Hobart Corehole 1	24	1S	14W	1964	5514
65	Standard Oil Co.	Wilton Corehole 1	25	1S	14W	1963	3459
65	Standard Oil Co.	Wilton Corehole 1 Redrill	25	1S	14W	1963	3816
66	Union Oil Co.	Union-Signal E.H. 28A	36	1S	14W	1964	5255
67	Union Oil Co.	Union-Signal E.H. 30	36	1S	14W	1965	6036
68	Standard Oil Co.	Venice Comm. 1	32	1S	13W	1964	Unkn.
69	Occidental Pet. Corp.	Occidental-Buttes-Stadium E.H. 1	20	1S	13W	1965	4476
70[3]	Union Oil Co.	Union-Paramount-U-14-1	14	1S	14W	1958	5339

[1] All wells drilled in the Elysian Park-Repetto Hills area before December 31, 1965.
[2] Section numbers in parentheses indicate projected section.
[3] Well No. 70 is west of the geologic map and is shown on the electric log correlation section (fig. 13).

Campbell, R. H., Yerkes, R. F., and Wentworth, C. M., 1966, Detachment faults in the central Santa Monica Mountains, California: U.S. Geol. Survey Prof. Paper 550-C, p. C1–C11.

Conrey, B. L., 1959, Sedimentary history of the early Pliocene in the Los Angeles basin, California: unpublished Doctor's thesis on file at Univ. of Southern Calif., Los Angeles, 273 p.

Corbató, C. E., 1963, Bouguer gravity anomalies of the San Fernando Valley, California: Univ. of Calif. Pubs. in Geol. Sci., vol. 46, p. 1–32.

Crowder, R. E., 1961, Los Angeles City oil field: Calif. Div. Oil and Gas, Summary of Operations, Vol. 47, p. 67–78.

David, L. R., 1943, Miocene fishes of southern California: Geol. Soc. of Am., Spec. Pap. 43, 193 p.

Daviess, S. N., and Woodford, A. O., 1949, Geology of the northwestern Puente Hills, Los Angeles County, California: U. S. Geol. Survey Oil and Gas Inv., Prelim. Map 83.

Dudley, P. H., Jr., 1954, Geology of the area adjacent to the Arroyo Seco Parkway, Los Angeles County, California: unpublished Master's thesis on file at Univ. of Calif., Los Angeles, 84 p.

Durham, D. L., and Yerkes, R. F., 1964, Geology and oil resources of the eastern Puente Hills area, southern California: U. S. Geol. Survey Prof. Paper 420-B, 62 p.

Durrell, Cordell, 1954, Geology of the Santa Monica Mountains, Los Angeles and Ventura Counties: Calif. Div. Mines, Bull. 170, map sheet no. 8.

Eaton, G. P., 1957, Miocene volcanic activity in the Los Angeles basin and vicinity: unpublished Doctor's thesis on file at the California Institute of Technology, Pasadena, California, 388 p.

Eckis, R., 1934, South coastal basin investigation, Geology and groundwater storage capacity of valley fill: California Div. Water Resources Bull. 45, 279 p.

Edwards, E. C., 1934, Pliocene conglomerates of Los Angeles basin and their paleogeographic significance: Am. Assoc. Petrol. Geol., Bull., vol. 18, p. 786–812.

Eldridge, G. H., and Arnold, Ralph, 1907, The Santa Clara Valley, Puente Hills and Los Angeles oil districts, southern California: U. S. Geol. Survey Bull. 309, 266 p.

English, W. A., 1926, Geology and oil resources of the Puente Hills region, southern California: U. S. Geol. Survey Bull. 758, 110 p.

Gay, T. E., Jr., and Hoffman, S. R., 1954, Mines and mineral deposits of Los Angeles County, California: Calif. Jour. of Mines and Geology, vol. 50, p. 467–709.

Gorsline, D. S., and Emery, K. O., 1959, Turbidity-current deposits in San Pedro and Santa Monica basins off southern California: Geol. Soc. Am., Bull., vol. 70, p. 279–290.

Hardey, G. W., 1958, Stratigraphy of the Topanga Formation in the eastern Santa Monica Mountains: unpublished Master's thesis on file at Univ. of Calif., Los Angeles, 85 p.

Harding, T. P., 1952, Geology of the eastern Santa Monica Mountains between Dry Canyon and Franklin Canyon: unpublished Master's thesis on file at Univ. of Calif., Los Angeles, 54 p.

Hertlein, L. G., and Grant, U. S., IV, 1944, The Cenozoic Brachiopoda of western North America: Univ. Calif., Los Angeles, Pub. Math. and Phys. Sci., vol. 3, p. 1–236.

Hill, M. L., and Dibblee, T. W., Jr., 1953, San Andreas, Garlock, and Big Pine faults, California: Geol. Soc. Am., Bull., vol. 64, p. 443–458.

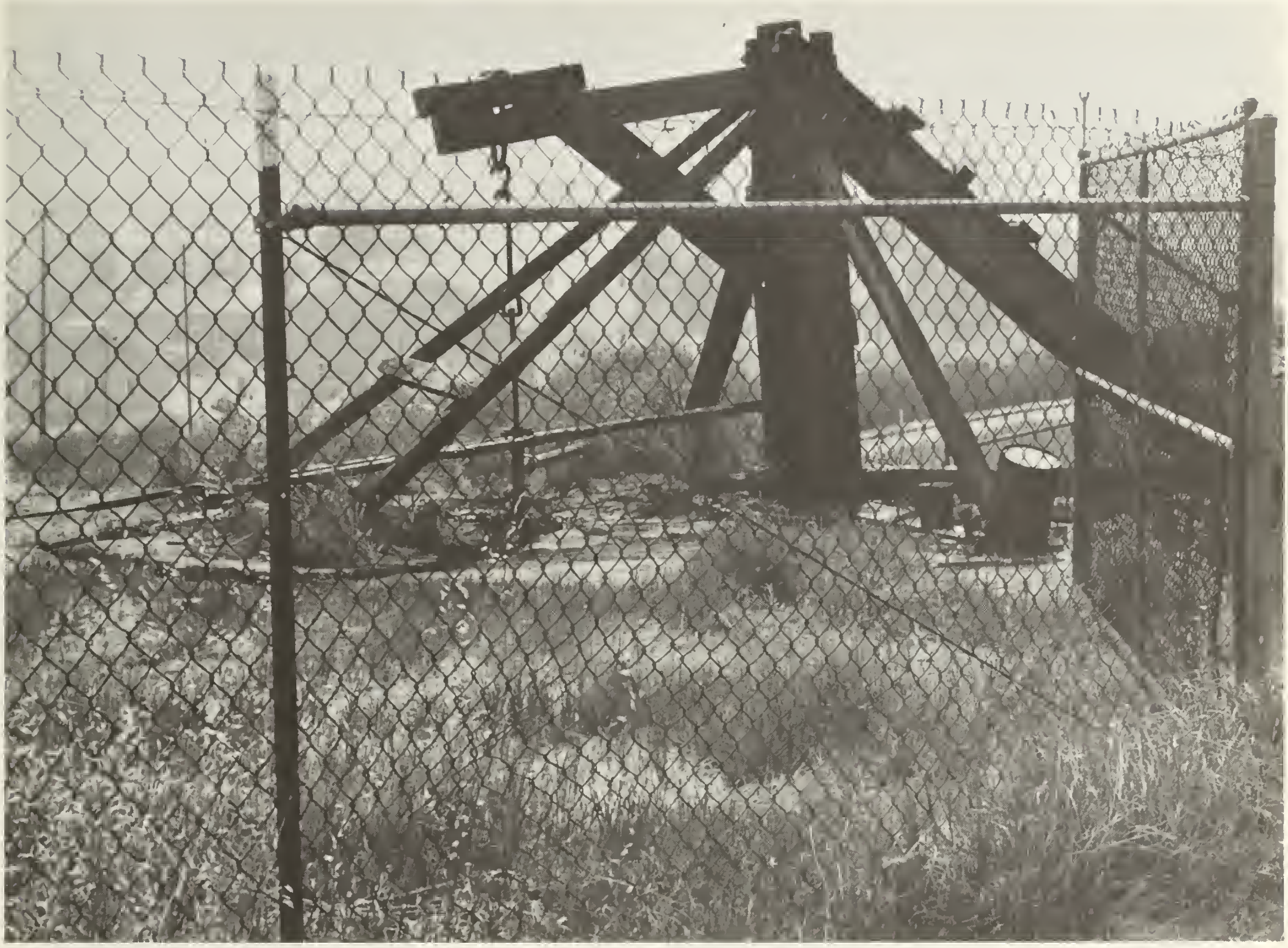


Figure 26. Oil Well at East End of Los Angeles City Oil Field.

Hoots, H. W., 1931, Geology of the eastern part of the Santa Monica Mountains, Los Angeles County, California: U. S. Geol. Survey Prof. Paper 165-C, p. 83–134.

Imlay, R. W., 1963, Jurassic fossils from southern California: Jour. of Paleo., vol. 37, p. 97–107.

Jaffe, H. W., Gottfried, D., Waring, C. L., and Worthing, H. W., 1959, Lead-alpha age determinations of accessory minerals of igneous rocks (1953–57): U. S. Geol. Survey Bull. 1097-B, p. 65–148.

Jamison, H. C., and Malloy, R. J., 1958, Boyle Heights oil field: in "A guide to the geology and oil fields of the Los Angeles and Ventura regions," Pacific Section of the Am. Assoc. Petrol. Geol., p. 98–99.

Jennings, C. W., and Troxel, B. W., 1954, Geologic guide for the Ventura basin: Calif. Div. Mines, Bull. 170, geologic guide No. 2, 63 p.

Kew, W. S. W., 1923, Geologic formations of a part of southern California and their correlation: Am. Assoc. Petrol. Geol., Bull., vol. 7, p. 411–420.

Kew, W. S. W., 1924, Geology and oil resources of a part of Los Angeles and Ventura Counties, California: U. S. Geol. Survey Bull. 753, 202 p.

Kleinpell, R. M., 1938, Miocene stratigraphy of California: Am. Assoc. Petrol. Geol., Tulsa, Oklahoma, 450 p.

Knapp, R. R., chairman 1962, Cenozoic correlation section across Los Angeles basin from Beverly Hills to Newport, California: Pacific Section of the Am. Assoc. Petrol. Geol.

Krueger, 1936, The Sycamore Canyon Formation: Am. Assoc. Petrol. Geol., Bull., vol. 20, p. 1520 (abstract).

Kuenen, Ph. H., and Carozzi, A., 1953, Turbidity currents and sliding in geosynclinal basins of the Alps: Jour. of Geol., vol. 61, p. 363–373.

Kulp, J. L., 1961, Geologic time scale: Science, vol. 133, p. 1105–1116.

Kundert, C. J., 1955, Los Angeles sheet, geologic map of California: Calif. Div. Mines.

Lamar, D. L., 1961, Structural evolution of the northern margin of the Los Angeles basin: unpublished Doctor's thesis on file at Univ. of Calif., Los Angeles, 142 p.

Martin, L., 1952, Some Pliocene Foraminifera from a portion of the Los Angeles basin, California: Contrib. from the Cushman Found. Foram. Research, vol. III, p. 107–141.

McCulloh, T. H., 1957, Simple bouguer gravity and generalized geologic map of the northwestern part of the Los Angeles basin, California: U. S. Geol. Survey Geophysical Inv. Map GP 149.

Miller, W. J., 1926, Crystalline rocks of the middle-southern San Gabriel Mountains, California: Geol. Soc. Am., Bull., vol. 37, p. 149 (abstract).

Miller, W. J., 1934, Geology of the western San Gabriel Mountains of California: Univ. Calif., Los Angeles, Pub. Math. and Phys. Sci., vol. 1, p. 1–114.

Miller, W. J., 1946, Crystalline rocks of southern California: Geol. Soc. Am., Bull., vol. 57, p. 457–542.

Natland, M. L., 1933, Temperature and depth ranges of some recent and fossil Foraminifera in the southern California region: Scripps Inst. Oceanog., Bull., Tech. Ser., vol. 3, no. 10.

Natland, M. L., 1952, Pleistocene and Pliocene stratigraphy of southern California: unpublished Doctor's thesis on file at Univ. of Calif., Los Angeles, 165 p.

Natland, M. L., 1957, Paleoecology of west coast Tertiary sediments: Geol. Soc. of Am. Mem. 67, vol. 2, p. 543–572.

Natland, M. L., and Rothwell, W. T., Jr., 1954, Fossil Foraminifera of the Los Angeles and Ventura regions, California: Calif. Div. Mines, Bull. 170, chapt. III, p. 33–42.

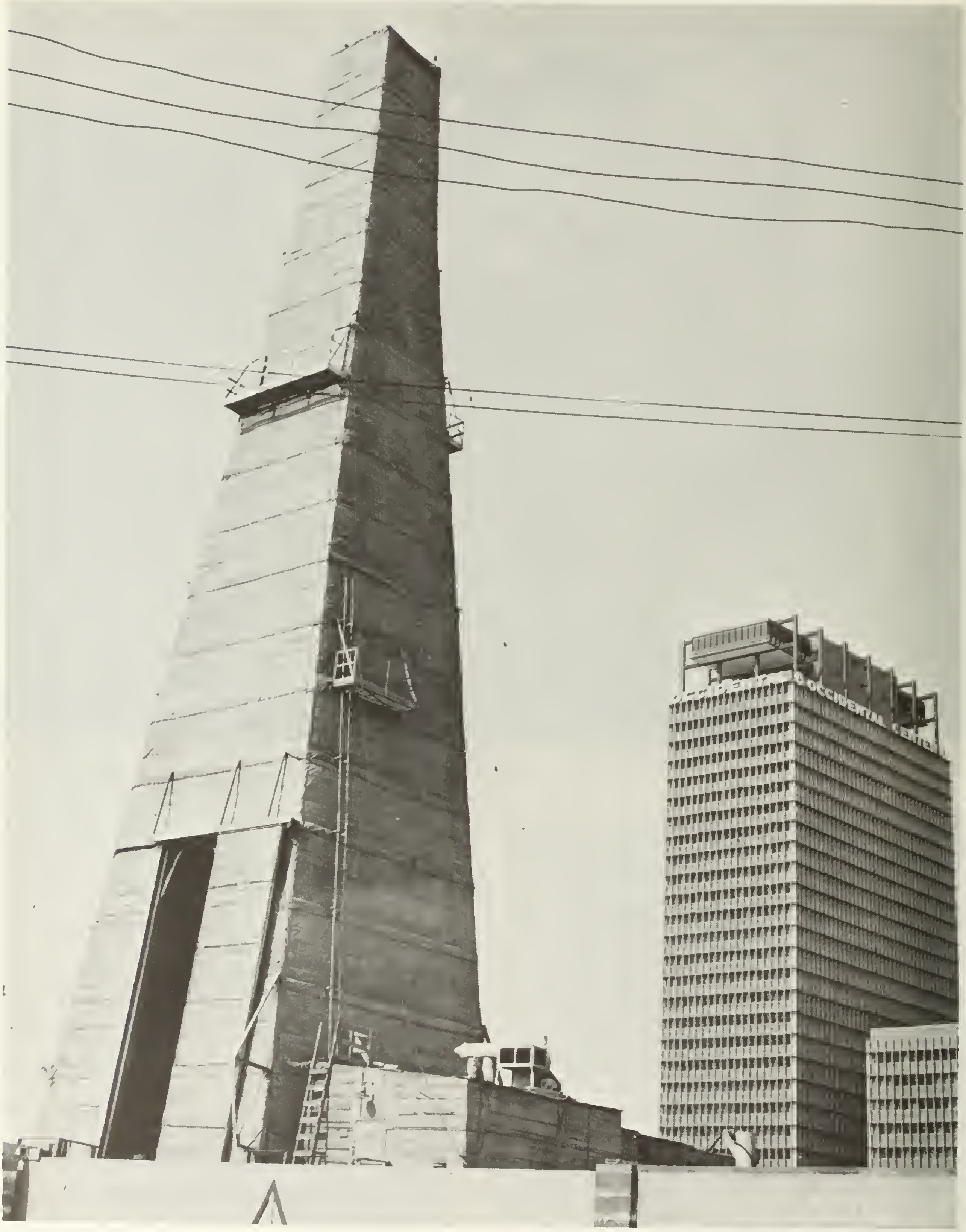


Figure 27. Oil Well, Downtown Los Angeles. The Standard Oil Company of California well is at the intersection of 14th Place and Broadway.

Neuerburg, G. J., 1951, Petrology of the pre-Cretaceous rocks of the Santa Monica Mountains, California: unpublished Doctor's thesis on file at Univ. of Calif., Los Angeles, 180 p.

Neuerburg, G. J., 1953, Geology of the Griffith Park area, Los Angeles County, California: Calif. Div. Mines, Spec. Rpt. 33, 29 p.

Pierce, R. L., 1956, Upper Miocene Foraminifera and fish from the Los Angeles area, California: Jour. of Paleo., vol. 30, p. 1288–1314.

Quarles, Miller, Jr., 1941, Geology of the Repetto and Montebello Hills: unpublished Master's thesis on file at the California Institute of Technology, Pasadena, California, 63 p.

Reed, R. D., 1929, Sespe Formation, California: Am. Assoc. Petrol. Geol., Bull., vol. 13, p. 489–507.

Reed, R. D., 1932, Section from the Repetto Hills to the Long Beach oil field: Int. Geol. Cong., guide book 15, p. 30–34.

Sanford, A. R., 1958, Gravity survey of a part of the Raymond and San Gabriel basins, southern California: Section II of a Doctor's thesis on file at the California Institute of Technology, Pasadena, California, p. 112–142.

Schoellhamer, J. E., and Woodford, A. O., 1951, The floor of the Los Angeles basin, Los Angeles, Orange, and San Bernardino Counties, California: U. S. Geol. Survey Oil and Gas Inv. Map OM117.

Schoellhamer, J. E., and Kinney, D. M., Yerkes, R. F., and Vedder, J. G., 1954, Geologic map of the northern Santa Ana Mountains, Orange and Riverside Counties, California: U. S. Geol. Survey Oil and Gas Inv. Map OM154.

Schoellhamer, J. E., and Yerkes, R. F., 1961, Preliminary geologic map of the coastal part of the Malibu Beach quadrangle, Los Angeles County, California: U. S. Geol. Survey Open File Map.

Schoellhamer, J. E., Yerkes, R. F., and Campbell, R. H., 1962, Preliminary geologic map of the coastal part of the Point Dume quadrangle, Los Angeles County, California: U. S. Geol. Survey Open File Map.

Shelton, J. S., 1946, Geologic map of the northeast margin of San Gabriel basin: U. S. Geol. Survey Oil and Gas Inv. Prelim. Map 63.

Silberling, N. J., Schoellhamer, J. E., Gray, C. H., Jr., and Imlay, R. W., 1961, Upper Jurassic fossils from Bedford Canyon Formation, southern California: Am. Assoc. Petrol. Geol. Bull., vol. 45, p. 1746–1748.

Smith, P. B., 1960, Foraminifera of the Monterey Shale and Puente Formation, Santa Ana Mountains and San Juan Capistrano area, California: U. S. Geol. Survey Prof. Paper 294-M, p. 463–495.

Soper, E. K., 1938, Geology of the central Santa Monica Mountains, Los Angeles County: Calif. Jour. of Mines and Geology, vol. 34, p. 131–180.

Soper, E. K., 1943, Los Angeles City oil field: Calif. Div. Mines, Bull. 118, p. 282–283.

Soper, E. K., and Grant, U. S., IV, 1932, Geology and paleontology of a portion of Los Angeles, California: Geol. Soc. Am., Bull., vol. 43, p. 1041–1068.

Sullwold, H. H., Jr., 1958, The Tarzana fan, a deep submarine delta of late Miocene age, Los Angeles County, California: unpublished Doctor's thesis on file at Univ. of Calif., Los Angeles, 159 p.

Sullwold, H. H., Jr., 1960, Tarzana fan, deep submarine fan of late Miocene age, Los Angeles County, California: Am. Assoc. Petrol. Geol. Bull., vol. 44, p. 433–457.

VanderHoof, V. L., 1953, Review of Sespe paleontology: Am. Assoc. Petrol. Geol., Bull., vol. 37, p. 2776 (abstract).

Vandiver, V. W., 1952, Field trip unit 4—Los Angeles City to Burbank road log: Am. Assoc. Petrol. Geol., field trip guidebook for joint annual meeting, Los Angeles, p. 24–26.

Vedder, J. G., Yerkes, R. F., and Schoellhamer, J. E., 1957, Geologic map of the San Joaquin Hills-San Juan Capistrano area, Orange County, California: U. S. Geol. Survey Oil and Gas Inv. Map OM193.

Watts, W. L., 1897, Oil and gas yielding formations of Los Angeles, Ventura, and Santa Barbara Counties: California State Mining Bureau, Bull. no. 11, 94 p.

Watts, W. L., 1901, Oil and gas yielding formations of California: California State Mining Bureau, Bull. no. 19, 224 p.

Winterer, E. L., and Durham, D. L., 1962, Geology of southeastern Ventura basin, Los Angeles County, California: U. S. Geol. Survey Prof. Paper 3534-H, p. 275–366.

Wissler, S. G., 1943, Stratigraphic formations of the producing zones of the Los Angeles basin oil fields: Calif. Div. Mines, Bull. 118, p. 209–234.

Wissler, S. G., 1958, Correlation chart of producing zones of Los Angeles basin oil fields: in "A guide to the geology and oil fields of the Los Angeles and Ventura regions," Pacific Section of the Am. Assoc. Petrol. Geol., p. 59–61.

Woodford, A. O., Schoellhamer, J. E., Vedder, J. G., and Yerkes, R. F., 1954, Geology of the Los Angeles basin: Calif. Div. Mines, Bull. 170, chapt. II, p. 65–81.

Woodring, W. P., 1938, Lower Pliocene mollusks and echinoids from the Los Angeles basin, California, and their inferred environment: U. S. Geol. Survey Prof. Paper 190, 67 p.

Yerkes, R. F., Campbell, R. H., Schoellhamer, J. E., and Wentworth, C. M., 1964, Preliminary geologic map and sections of southwest part of the Topanga quandrangle: U. S. Geol. Survey Open File Map.

Yerkes, R. F., McCullah, T. H., Schoellhamer, J. E., and Vedder, J. G., 1965, Geology of the Los Angeles basin, California—an introduction: U. S. Geological Survey Prof. Paper 420-A, 57 p.

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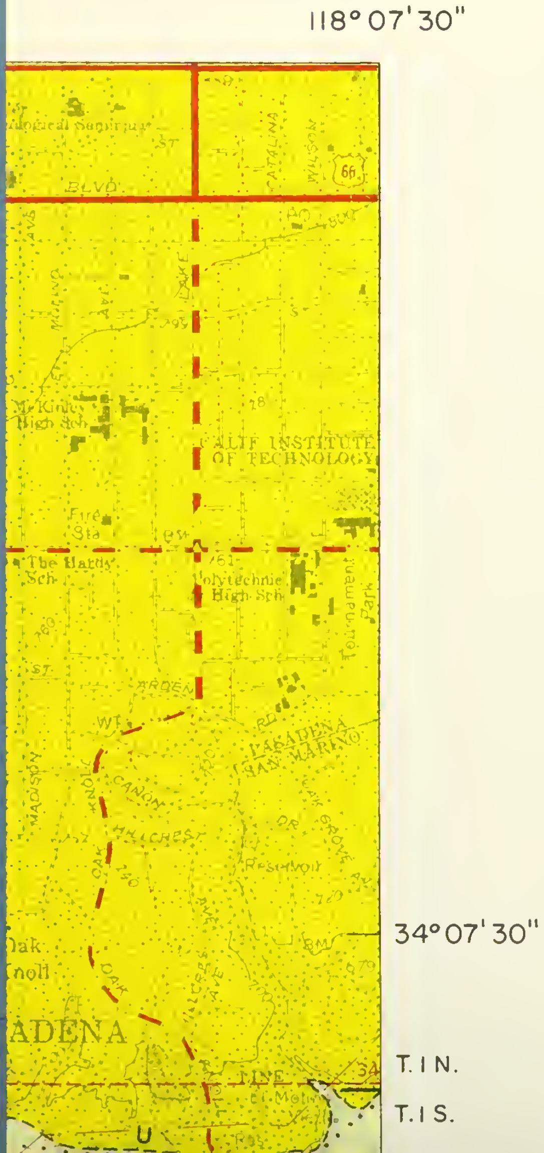
SPECIAL REPORT 101
PLATE 1



RECENT

PLEISTOCENE

Silt, sanc
alluvial p

Silt, sanc
and dissec

PLIOCENE

Tfcg: con
Tfss: sand
light tan c
light gray

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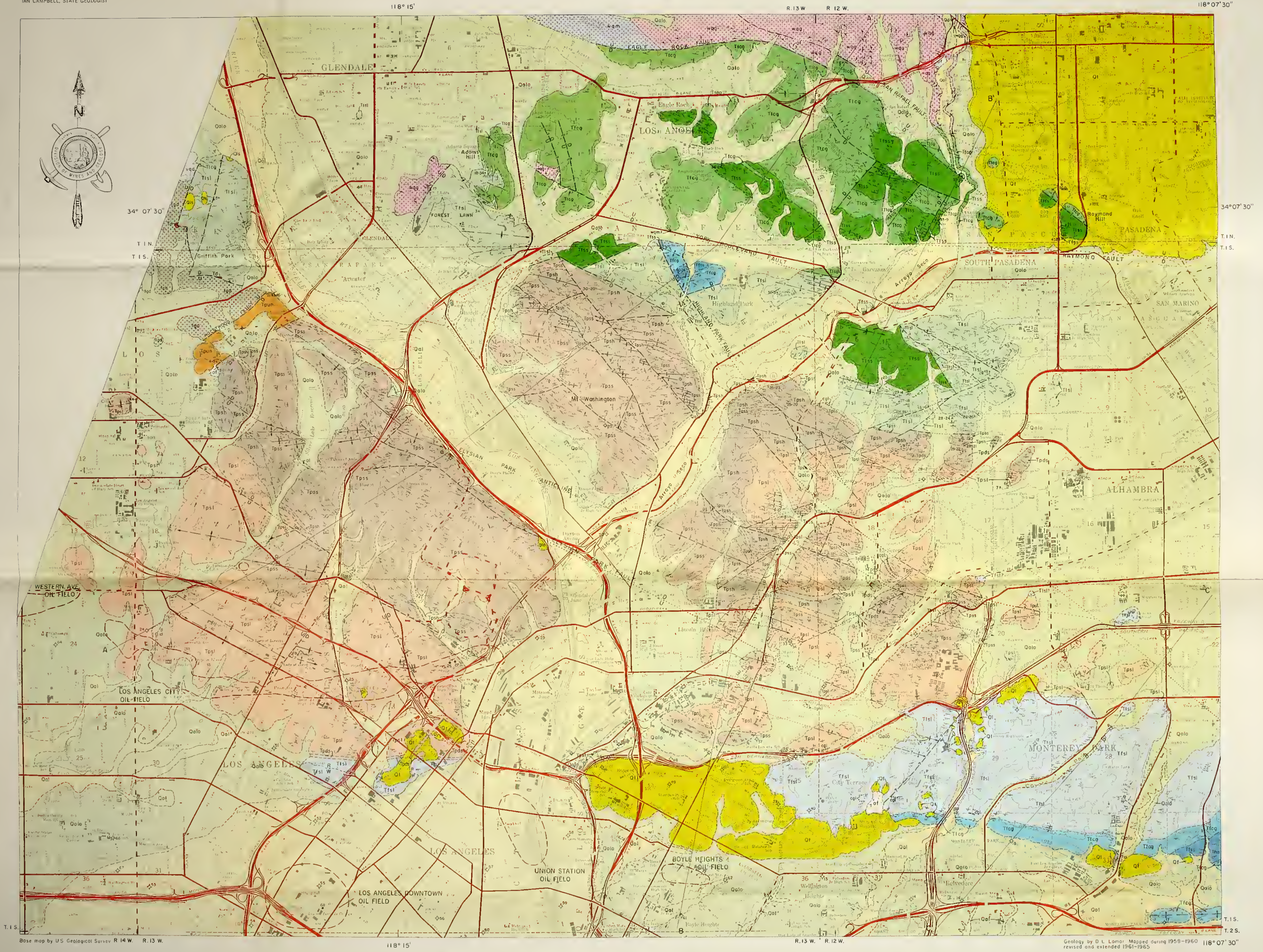
IAN CAMPBELL, STATE GEOLOGIST

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF CONSERVATION

SPECIAL REPORT 101
PLATE 1



Base map by U.S. Geological Survey

Geology by D. L. Lamar. Mapped during 1958-1960 revised and extended 1961-1965

EXPLANATION

QUATERNARY

RECENT

af
Artificial fill

Qal
Alluvium
Silt, sand and gravel.

Qls
Landslide debris

PLEISTOCENE

Qalo
Old alluvium
Silt, sand and gravel forming dissected alluvial plain and alluvial terrace deposits.

Ql
Terrace Deposits
Silt, sand and gravel forming alluvial terrace and dissected alluvial plain deposits.

TERTIARY

PLIOCENE

Tfcg
Tfss
Tfsl R/W

Fernando Formation
Tfcg: conglomerate, light to red brown, Tfss: sandstone, fine- to medium-grained, light tan and brown; Tfsl: siltstone, massive, light gray; R/W: Repettian-Wheelerian Stage boundary

UPPER MIOCENE

Tpsl
Tpsh
Tpds
Tpss
Tpun

Puente Formation
Tpsl: siltstone, well bedded, light brown and light gray; Tpsh: shale, well bedded, light gray, siliceous; Tpds: diatomaceous shale, punky, dull white; Tpss: sandstone, well bedded, medium- to coarse-grained, light brown to gray; Tpun: undifferentiated siltstone, shale, sandstone, and conglomerate.

MIDDLE MIOCENE

Tlss
Tlcg
Tlsl

Topanga Formation
Tlss: sandstone, medium- to coarse-grained, well bedded, brown; conglomeratic north of York Boulevard fault; Tlcg: conglomerate, massive to well bedded, light brown; breccia at base north of York Boulevard fault; Tlsl: siltstone, well bedded, medium to dark brown, with interbedded sandstone, shale and chert.

Td
Diabase
Dark red brown, deeply weathered.

CRETACEOUS (?)

wqm
wqg

Wilson Quartz Diorite
wqm: massive, medium- to coarse-grained, light brown, wqg: gneissic, minor amounts of schist. Includes unmapped granodiorite dikes.

vqd
Vermont Quartz Diorite
Fine- to medium-grained, massive, brown.

fgd
Feliz Granodiorite
Fine- to medium-grained, massive, light gray to light brown.

Lithologic symbols for individual beds and small areas of exposure:

cgl: conglomerate
ss: sandstone
t: tuff

Contact
Dashed where approximately located, querried where inferred.

Fault, showing dip
Dashed where approximately located, querried where inferred or hypothetical, dotted where concealed. U: up-thrown side; D: down-thrown side; arrows indicate relative movement. Only horizontal separation demonstrated by offset of structures within map area are indicated. See text for discussion of possible magnitude and direction of horizontal movement on major faults based on regional distribution of rocks.

Anticline
Syncline
Axial planes of folds; arrows indicate dip direction on flanks and plunge; dashed where approximately located.

Strike and dip of beds

Strike and dip of beds inferred to be overturned.

Horizontal beds

Vertical beds

Component of dip, strike unknown.

Strike and dip of beds with grading or other sedimentary structures indicating tops.

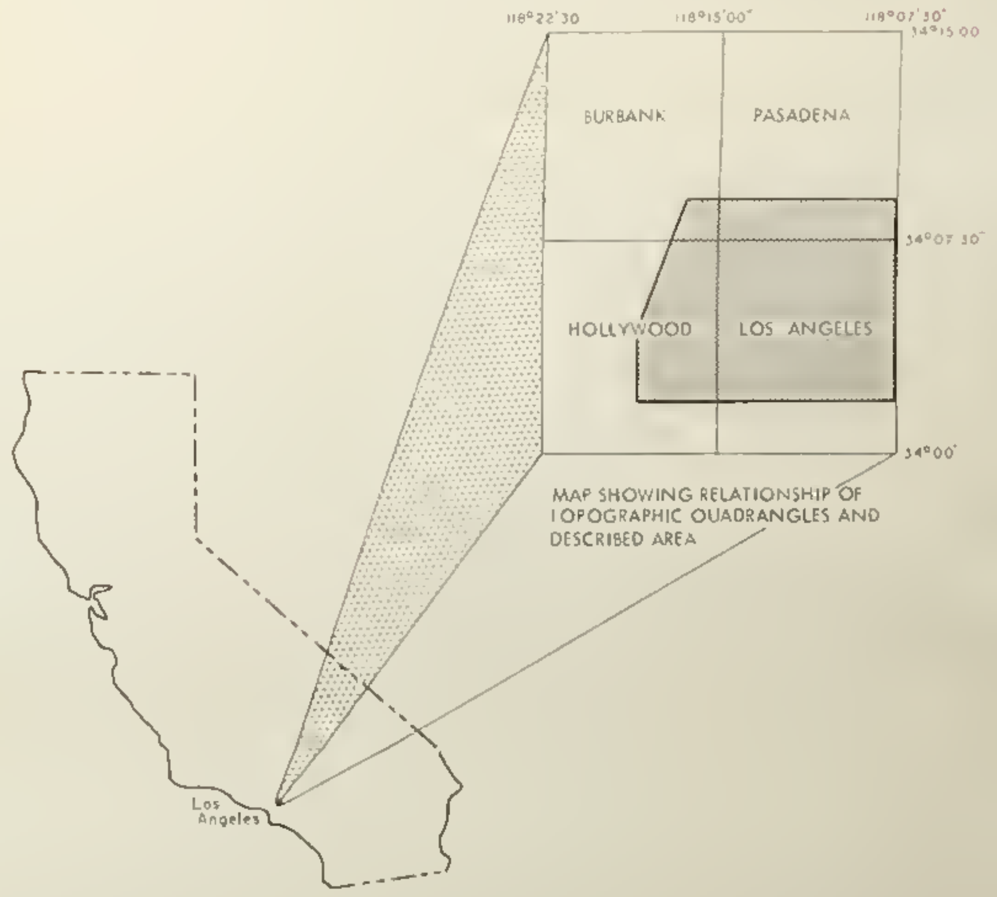
Strike and dip of foliation

Dry hole
Producer

Numbers refer to list of wells drilled for oil in text. Circle indicates surface location of directed wells. Not all old wells and wells in oil fields are shown.

Limits of oil field

Fossil locality



MAP SHOWING RELATIONSHIP OF TOPOGRAPHIC QUADRANGLES AND DESCRIBED AREA

GEOLOGIC MAP OF THE ELYSIAN PARK-REPETTO HILLS AREA, LOS ANGELES COUNTY, CALIFORNIA

SCALE 1:24000

1000 0 2000 4000 6000 8000 FEET

CONTOUR INTERVAL 5 AND 25 FEET

1970

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STATE OF CALIFORNIA
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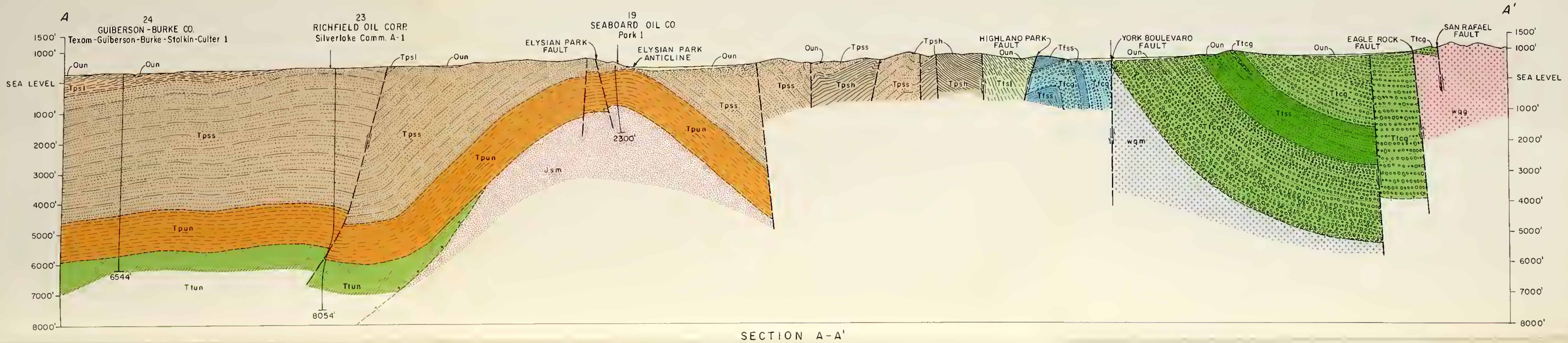
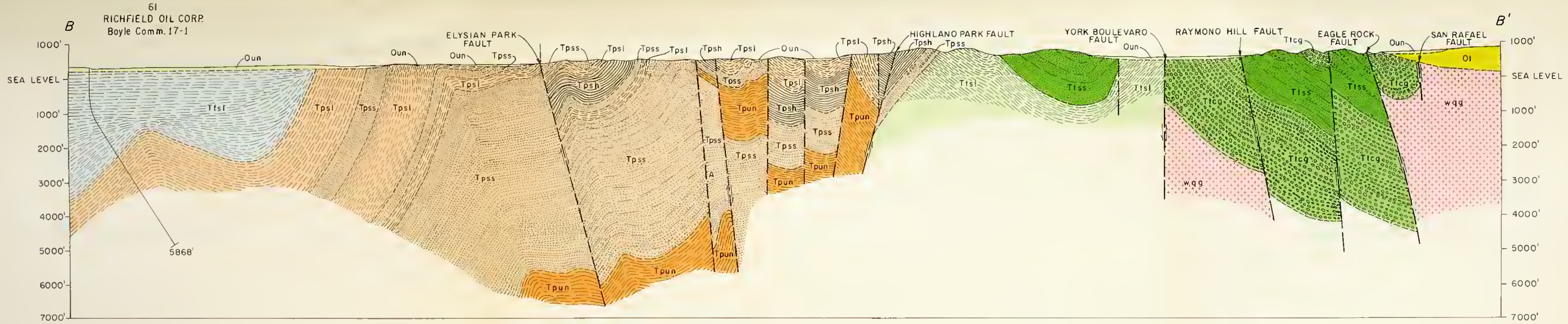
PLATE 2



SECTION A-A'



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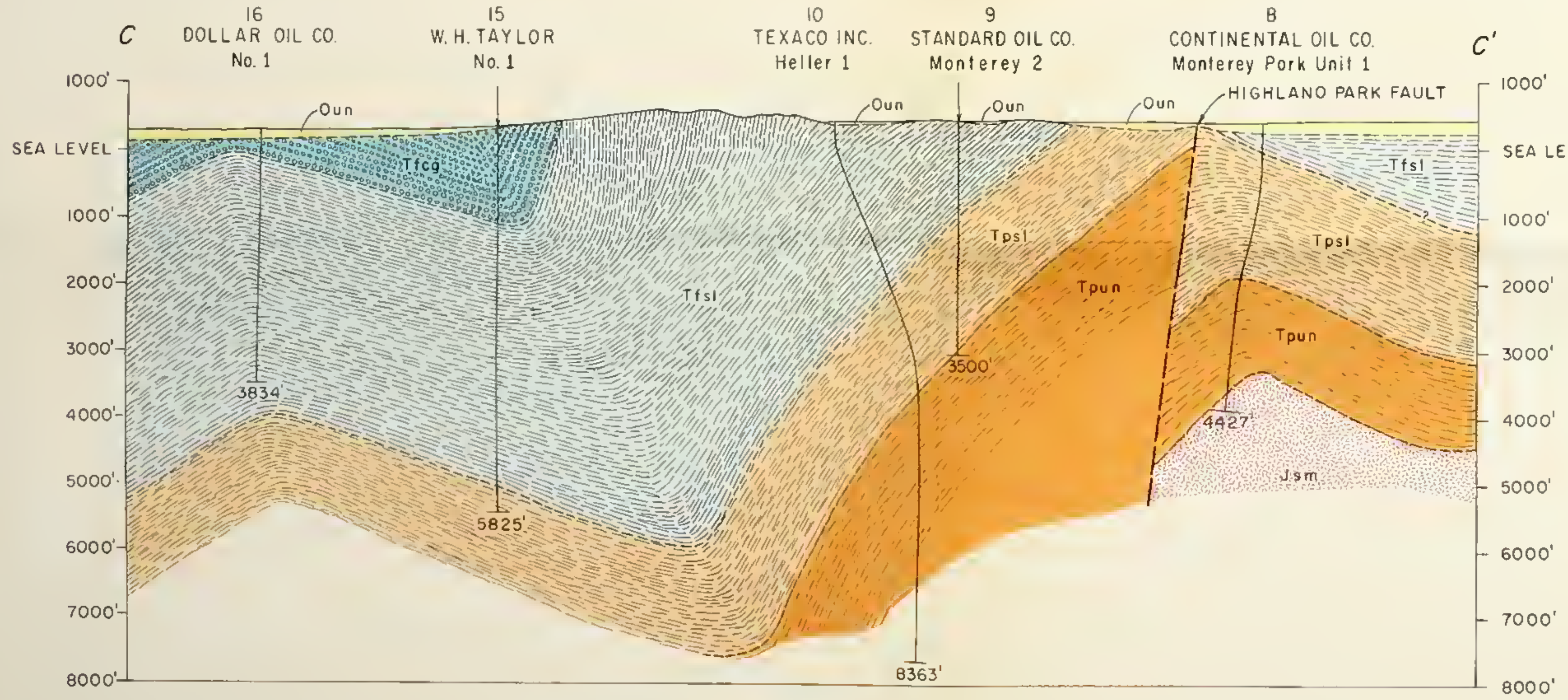

SECTION C-C'

EXPLANATION

QUATERNARY
PLEISTOCENE

- Oun — Undifferentiated alluvium and terrace deposits
- Ol — Terrace deposits

TERTIARY
PLIOCENE
FERNANDO FORMATION

- Tfcg — Conglomerate
- Tfss — Sandstone
- Tfsl — Siltstone

UPPER MIOCENE
PUENTE FORMATION

- Tpsl — Siltstone
- Tpsh — Shale
- Tpss — Sandstone
- Tpun — Undifferentiated sedimentary rocks

TERTIARY
MIDDLE MIOCENE
TOPANGA FORMATION

- Ttss — Sandstone
- Ttcg — Conglomerate
- Ttsl — Siltstone
- Ttun — Undifferentiated sedimentary rocks

JURASSIC CRETACEOUS(?)

- wqm / wqg — Wilson Quartz Diorite
wqm: massive; wqg: gneissic

JURASSIC

- Jsm — Santa Monica Slate

A|T
Fault
Arrows indicate relative movement
T is side that moved toward observer;
A is side that moved away

LITHOLOGIC SYMBOLS

- ▤ Shale
- ▤ Siltstone
- ▨ Sandstone
- ○ Conglomerate

↓ Bend in section

See plate 1 for location of lines of section

GEOLOGIC SECTIONS ACROSS THE ELYSIAN PARK – REPETTO HILLS AREA, LOS ANGELES COUNTY, CALIFORNIA

SCALE 1:24000

1000 0 2000 4000 6000 8000 FEET

1970

Geology by D. L. Lamar. Mapped during 1958–1960; revised and extended 1961–1965.